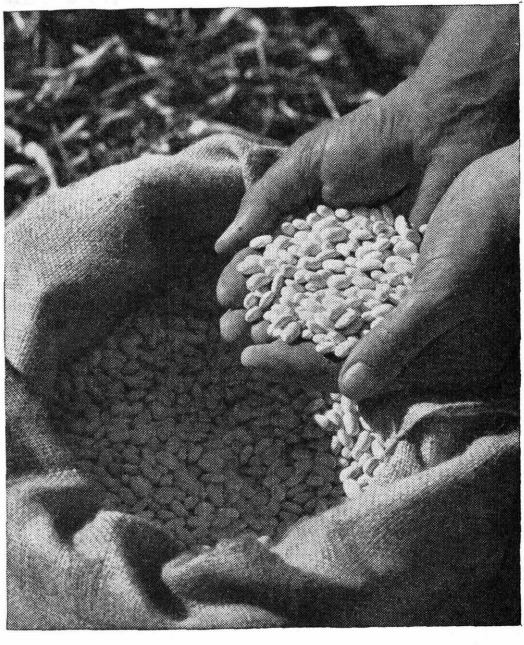
Growing Dry Beans *in the* WESTERN STATES



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DRY BEANS are successfully grown on both irrigated and non-irrigated lands in the Western States. They are grown under a variety of soil and climatic conditions, but a major part of the crop is in fairly distinct areas of seven States. The exact location is influenced by competing crops, the length of the growing season, the moisture that is available, and freedom from disease and insects, or the practicability of controlling the diseases and insects. These conditions also help to decide the type or variety of bean best adapted to each area.

Beans fit well into rotations on many farms. They are an important cash crop and both the straw and the cull or damaged beans can be used as feed for livestock.

Practically the same farm machinery that is used in producing other farm crops is used for beans. Special combines or threshers are used in some areas, but regular combines and threshers can be adjusted to do a satisfactory job on beans.

This bulletin describes briefly the usual farming practices, the seeding rates, varieties of beans, and harvesting methods, as they are found in the major bean-producing areas of the West. It describes common insect pests and diseases briefly, so they may be identified, and gives recommendations for controlling them. It supersedes Farmers' Bulletin 1509, Bean Growing in Northern Idaho, Eastern Washington, and Eastern Oregon.

Members of the staffs of agricultural experiment stations in California, Colorado, Idaho, New Mexico, Nebraska, and Wyoming supplied information or reviewed the manuscript of this publication. Members of the Bureau of Agricultural Economics, the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Production and Marketing Administration made suggestions and assisted in various ways.

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GROWING DRY BEANS IN THE WESTERN STATES

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Contents

DRY EDIBLE BEANS are now an important cash crop in 6 States and they bring a valued income to many growers in more than 10 other States. Beans are adapted to a variety of soils and climatic conditions. They are sensitive to a very alkaline or a very acid condition of the soil, but are not sensitive to the character of the soil so long as it is reasonably fertile, well-drained, and of such a nature that it does not interfere with the germination and emergence of the plants.

Beans are a comparatively short-season crop and so may escape damage from drought. They are not resistant to drought but some varieties can wait for the soil moisture they need during the fruiting stage. Though a warm-season crop, beans do not thrive where temperatures go extremely high. A few hot dry days at blossom time may mean severe damage from blossom drop. Cool humid or rainy weather is also unfavorable to beans but they are adapted to a fairly wide range of temperature. Preferably they should have monthly means of 65° to 75° F., but they are not tolerant to frost or to prolonged exposure to weather that is near freezing. The frost-free growing season must be about 120 days to 130 days, depending on the variety. Some varieties mature in 90 days after planting, but the

frost-free period should be longer than this. This broad tolerance or adaptability of the plant would probably mean that physically the crop is suited to much more than 3,000,000 acres, as compared with the record plantings of 2,600,000 acres in 1943.

Beans are a concentrated direct food and are high in protein, phosphorus, iron and vitamin B_1. They are readily stored and transported. In wartime, when labor was scarce and food requirements were great, beans ranked high on the list of strategic food crops. During World War II the planted acreage averaged more than 2 million acres, with a production of 14 to 19 million bags. The acreage usually fluctuates freely between 1,700,000 and 2,200,000. The average production during 1937–41 was 16,400,000 bags from 1,977,000 acres.

Dry beans are grown commercially in 21 States, but more than 90 percent of the crop during 1937–41 was grown in 6 States. Ranked according to total production during this period, California with more than 30 percent of the total stood first, followed by Michigan with 29.5 percent, then Idaho, Colorado, New York, and New Mexico. Next came Wyoming, Nebraska, Montana, and Arizona.

To facilitate conciseness in this bulletin the principal bean-producing regions in the West are grouped into two major areas: (1) Nonirrigated and (2) irrigated. The principal varieties grown in the Western States differ from those grown in the eastern humid areas, although there is some overlapping (fig. 1). Climate is the main reason for this distribution of types. The several types are not far apart in their requirements of mean temperature, but they are quite different in their requirements of water and in tolerance to drought or excessive moisture and to daily maximum temperatures. The recommended cropping practices and machinery also vary widely between areas.

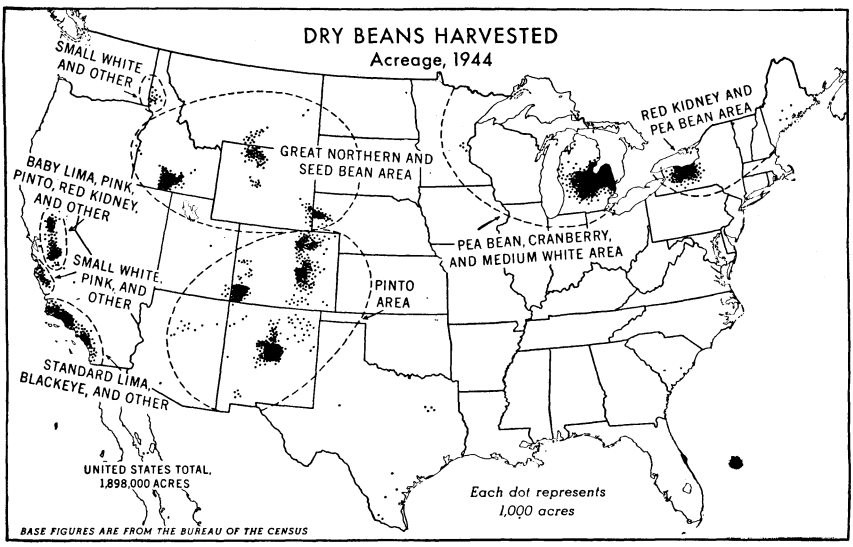

FIGURE 1.—The 15 major types of beans are mostly concentrated in 9 States. There is some overlapping of types among areas and States, but the major producing areas for each type are fairly distinct.

The most important things that determine the type or variety of bean for a given area are seasonal rainfall or available irrigation water, length of growing season, prevalence of disease, market preferences, and crop rotations.

Advice on safe planting dates, recommended varieties, and rates of seeding, fertilizer, rotations, and problems for local areas may be obtained from State colleges of agriculture, county agricultural agents, and others who are acquainted with the local situation. Abandonment of acreage because of hailstorms, drought, insects, disease, or other cause is a problem in many areas. It varies widely among States and from year to year. Acreage abandonment from 1942 through 1946 among the major States ranged from about 2 percent in California to more than 16 percent in New Mexico. In Michigan and New York it was above 8 and 9 percent, respectively, during this 5-year period. In some years the abandonment due to drought and other things, is extremely high in some of the dry-land areas. In 1934 more than half the acreage planted in Nebraska, two-thirds of that in Colorado, and almost four-fifths of that in New Mexico was abandoned.

IRRIGATED AREAS

Dry beans are an important cash crop in many irrigated areas and in some they are the principal cash crop. About four-fifths of the 1939 crop in the Western States was on irrigated land (table 1). Nearly all of the Great Northern, Small White, Red Kidney, Bayo, Cranberry, Pink, Blackeye, Mexican Red, and many of the Lima, Pinto, and other varieties are grown under irrigation.

TABLE 1.—*Acreage and percentage of acreage and production on irrigated and nonirrigated land in selected States, 1939*

State	Acreage irrigated	Acreage nonirrigated	Total	Percentage of total acreage		Percentage of total production	
				Irrigated	Nonirrigated	Irrigated	Nonirrigated
	Acres	*Acres*	*Acres*	*Percent*	*Percent*	*Percent*	*Percent*
Arizona	3, 515	11, 984	15, 499	22. 7	77. 3	44. 2	55. 8
California	179, 313	107, 299	288, 612	62. 1	37. 9	76. 0	24. 0
Colorado	92, 302	148, 686	240, 988	38. 3	61. 7	77. 5	22. 5
Idaho	77, 456	21, 681	99, 137	78. 1	21. 9	94. 0	6. 0
Kansas	4	57	61	6. 6	93. 4	13. 7	86. 3
Montana	13, 769	43	13, 812	99. 7	. 3	99. 9	. 1
Nebraska	14, 643	576	15, 219	96. 2	3. 8	99. 5	. 5
New Mexico	18, 021	175, 670	193, 691	9. 3	90. 7	28. 9	71. 1
Oregon	524	691	1, 215	43. 1	56. 9	54. 5	45. 5
Utah	3, 565	2, 878	6, 443	55. 3	44. 7	81. 3	18. 7
Washington	1, 363	2, 154	3, 517	38. 8	61. 2	43. 3	56. 7
Wyoming	43, 550	4, 625	48, 175	90. 4	9. 6	98. 8	1. 2
Total	448, 025	476, 344	924, 369	48. 5	51. 5	79. 4	20. 6

1940 Census of Agriculture.

The principal dry-bean irrigated areas are in southern Idaho, central and southern California, the Big Horn Basin of Wyoming, western Nebraska, northeastern and other localities in Colorado, the Yellowstone Valley in Montana, and central New Mexico. Pump irrigation from ground water is increasing in New Mexico. Among these areas there is considerable difference in cropping practices and in the varieties grown. In some, beans are one of the main cash crops. In others, they are a minor crop and the rotation is built around sugar beets or potatoes.

PLACE IN THE CROPPING SYSTEM

Beans are not a soil-improving crop and should be rotated with other crops which conserve and renew the supply of organic matter in the soil. Commercial beans are often grown 3 to 5 years on the same land, and sometimes as many as 8 or more years in succession but this is bad practice under most conditions. It is often not desirable to have beans on the same land more than 2 years in succession. Growing them for longer than that in southern Idaho, for example, reduces the organic matter in the soil so much that irrigation water does not penetrate readily. This tends to increase erosion on any land that has much slope, particularly if the land is not worked on the contour. Growing beans after beans makes land that is subject to wind erosion more likely to blow. Some insects and diseases may be decreased by proper rotations.

In California, beans are frequently grown year after year, with no apparent decline in yield, but rotation of crops is probably desirable even there from the standpoint of disease and pest control, and rotation may increase the yields substantially.

The most frequent rotation in California bean areas is:

3–5 years	Alfalfa.
2 years	Beans.
1 year	Sugar beets, tomatoes, or other row crops.
1–2 years	Beans or other row crops.
3–5 years	Alfalfa.

On the west side of the San Joaquin Valley, in the Salinas Valley, and in southern California, a considerable part of the bean acreage is double-cropped, being planted to winter-growing vegetables such as lettuce, carrots, celery, and peas, after the beans are harvested.

In some areas beans are a good crop for planting between rows in young orchards and vineyards (fig. 2). They may bring in good income and, in a sense, they may bear a share of the cost of bringing young orchards into full bearing.

Either alfalfa or clover is common in all rotations in irrigated areas. Alfalfa is commonly grown for 3 to 4 years in succession, and often longer. It is recommended, however, that alfalfa be plowed up before the stand deteriorates enough to reduce yield appreciably. This would be likely to increase the yields of hay and make way for other crops.

Many successful bean growers in south-central Idaho follow alfalfa or clover with two or more years of beans. Then the land is seeded to grain or seed peas, which serve as a companion crop for alfalfa or clover. Sweetclover used as green manure can be used to restore organic matter to the soil without losing a single year in cash crops. The clover can be plowed under in the spring in time for beans to be planted. Rye is used as green manure also, but clover is more common

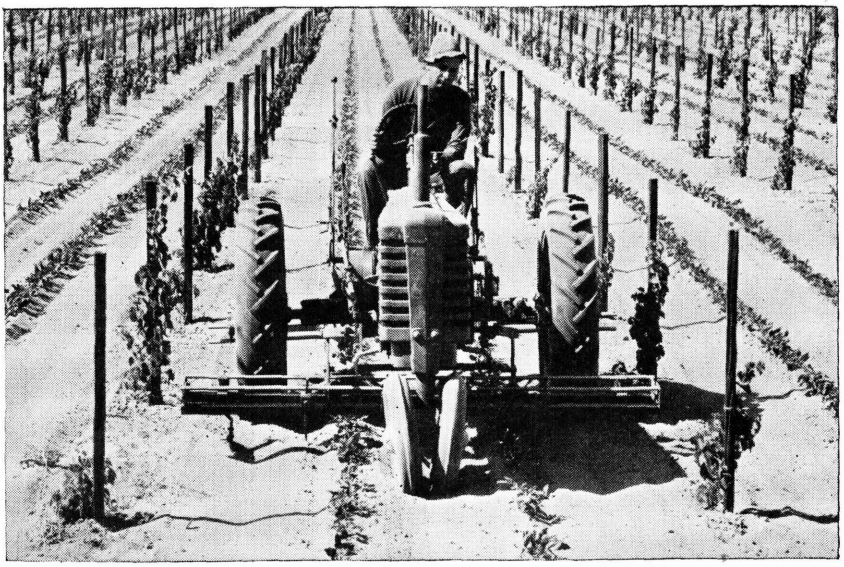

FIGURE 2.—Cultivating black-eyed beans in 30-inch rows between 9-foot rows of young grapes, near Stockton, Calif. Dry beans often are a good crop to plant between rows of young orchards.

and more valuable. Sometimes the last cutting of alfalfa is plowed under for green manure. Areas that are heavily infested with wireworms must depend more on alfalfa to rebuild or maintain organic matter in the soil, because sweetclover or other clovers favor wireworms.

If beans and potatoes are grown on the same farm in south-central Idaho, two or more years of beans often follow potatoes in a rotation of: alfalfa or clover, potatoes, beans, and a small grain seeded with alfalfa or clover. If the soil is too shallow for potatoes, beans may follow the alfalfa or clover. On farms that grow beans, potatoes, and sugar beets, the beans commonly follow potatoes on the less fertile land, the beets follow potatoes on the most fertile land. A notable exception is found in the case of seed beans of garden varieties, which make up about a fifth of the dry-bean acreage in Idaho. These contract varieties are often planted on more fertile land than the regular commercial varieties and are given a more favored place in the rotation. The regular varieties, however, respond well to fertile land.

In Colorado and Nebraska, beans usually follow potatoes in a rotation of small grain (with alfalfa), alfalfa, alfalfa, potatoes, beans, beets. Beans or corn may be planted instead of potatoes or sugar beets in some areas. The rotation can be shortened 1 or 2 years when sweetclover replaces alfalfa as the soil-building crop but if the rotation includes potatoes it should cover at least 4 years, to control scab. Some of the more successful farmers plow under a green manure before planting their beans. Fall rye or winter wheat is recommended for preventing wind erosion in winter. Either may be planted at the same time the beans are cut. Seeding rye by airplane before the beans are cut has some promise in Colorado. Listing is also used to prevent blowing.

In the irrigated bean areas of Montana and Wyoming the chief farm crops are sugar beets, grain, and alfalfa. Beans usually follow either alfalfa or grain. They do not follow beets well unless manure is added to stimulate growth. The most favored place for beans is after small grain. The Montana Agricultural Experiment Station recommends this, and suggests that farmers seed sugar beets after beans in such rotations as the following:

6-year rotation:
Barley (alfalfa).
Alfalfa.
Alfalfa.
Oats.
Beans.
Sugar beets (manure and phosphate).

9-year rotation:
Barley (alfalfa).
Alfalfa.
Alfalfa.
Alfalfa.
Oats.
Beans.
Sugar beets (manure and phosphate).
Oats.
Sugar beets (manure and phosphate).

In each of these rotations a third of the land would be in cash crops, a third in feed grains, and a third in alfalfa. Each would provide feed for livestock, either the year around or for winter feeding. A livestock enterprise not only provides manure for maintaining soil fertility, but makes a better balanced and more profitable farm organization.

PREPARING THE LAND

A well-prepared seedbed is a necessity if yields are to be satisfactory. Fall plowing is generally recommended for all crops in irrigated areas, unless wind erosion is serious. Spring plowing is satisfactory in sandy loam areas. On alfalfa land, "crowning" in the fall with a deeper plowing in the spring is good farm management. Plowing under alfalfa as green manure is common in some areas. The proper

FIGURE 3.—Preparing land with a two-way moldboard plow.

way in such cases is to plow under the last cutting in the fall, leaving the land rough during the winter. In the spring it can be worked pretty much as desired as no spring plowing is necessary. The two-way moldboard plow shown in figure 3 is used by many growers but other kinds of plows are often used, too.

Spring plowing is more common than fall plowing in some places. Many farmers disk their alfalfa or grain stubble in the spring, before they plow, to chop up any coarse materials that might interfere with later tillage. Sometimes, in areas that are not subject to blowing or wind erosion, and when beans follow beans several years in succession, the land is plowed only every 2 or 3 years. In other years it is disked. After the land is disked or plowed in the spring it is kept in condition and free of weeds mostly by harrowing and disking until just before planting time. It is often desirable or necessary to go over the land once or twice with a float before the planting, to prepare the land for irrigation. A packer may be used after harrowing and before leveling. This is the usual way in Montana and Nebraska when the land is spring-plowed.

The usual operations in preparing the seedbed in four areas are summarized as follows:

South-central Idaho:
- Plow.
- Harrow.
- Disk.
- Harrow.
- Float.
- Corrugate.
- Irrigate.
- Harrow.
- Plant.

California:
- Fall:
  - Disk straw under and subsoil or plow.
- Spring:
  - Harrow and/or chisel.
  - Float.
  - Cyclone weed.

California—Continued
- Spring—Continued
  - Furrow out for preirrigation in some areas.
  - Harrow (2 or more times).
  - Plant.

Montana:
- Plow.
- Harrow (3 or more times).
- Float.
- Pack.
- Plant.

Western Nebraska:
- Plow or disc.
- Harrow (1 to 3 times).
- Float (1 to 2 times).
- Pack.
- Plant.

Both spring-tooth and spike-tooth harrows are in common use.

Irrigating before the planting is common in some areas and is done in other areas unless there is enough moisture to make a good stand. This is generally recommended as preferable to "irrigating up," and makes it easier to obtain a good seedbed. In some cases the irrigation comes soon after the planting to soften the heavy crust so the young seedlings can get through, particularly on heavy soils. If this is done, throwing a small ridge of soil over the row to be knocked off after irrigating, is good practice.

FERTILIZATION

Fertilizer is not commonly used on irrigated bean land. It is more common to plant beans after crops which were fertilized, if fertilizer is used at all. But beans respond well to fertile soil and large yields depend on high fertility. If they follow beets in the rotation it may be desirable to add manure. It is usual in southern Idaho to apply manure to other crops, usually sugar beets or potatoes. Phosphate is often applied to alfalfa and sweetclover there, the recommended rate

per acre being 100 pounds of available phosphoric acid (P_2O_5). Even heavier applications on alfalfa may be profitable because of the residual effects on beans or other crops. Nitrogenous fertilizer on beans in southern Idaho may be effective, but the experiments have not gone far enough to justify definite recommendations for its use.

Considerable experimental work with fertilizers for beans in irrigated areas has been done, but much more is needed so that farmers may know the proper time to use fertilizer, the best methods of applying, and the quantities that should be used. The present recommendation in Nebraska is 200 pounds to the acre at time of planting, of a 10–20–0 fertilizer, if a farmer believes it is desirable to fertilize.

In Yellowstone Valley some manure is used on beans, but sugar beets and, to some extent, potatoes have first claim on the manure and on the best land. Beets in this area also receive phosphate, and there is usually enough residue to take care of other crops in the rotation.

VARIETIES

The best variety of bean for any one area depends on such things as soil type, length of growing season, humidity and temperature, prevalence of disease, and established markets. Changes in prices among the varieties, and the size of the crop in other areas should also be considered. The Small Red, for example, is well adapted to California conditions and at one time was grown almost exclusively there but it is so well adapted in Idaho that most of the crop is now grown in that State. The quick-maturing Great Northern is distinctly a product of the high-altitude irrigated valleys of the West. It is grown mostly in Idaho, Wyoming, Nebraska, and Montana.

Farmers unfamiliar with an area are advised to consult with locally experienced growers, with the county agricultural agent, or with the State agricultural experiment station for the latest recommendations regarding varieties and best sources of seed. Efforts are always being made to develop improved varieties. The best variety today may be second-best tomorrow.

The Idaho Agricultural Experiment Station has developed several varieties and strains of Great Northern and Red Mexican beans which are resistant to several viruses. These are Great Northern U. I. (University of Idaho) Nos. 15, 59, 81 and 123 and Red Mexican U. I. Nos. 3 and 34. Great Northern U. I. 15 and Red Mexican U. I. Nos. 3 and 34 are resistant to common bean mosaic and curly top. Great Northern U. I. Nos. 59, 81, and 123 are resistant to common bean mosaic and to a new strain of this virus.

In general, the horticultural characteristics of the new Great Northerns and Red Mexicans resemble those of the standard varieties. The size of seed, the shape, and color, of U. I. 15, 59, and 123 are closely like the general type of commercial Great Northerns, but the U. I. 81 is slightly smaller. U. I. 59, 81, and 123 require about 90 days to reach maturity and U. I. 15 requires about 95 days. The earlier maturing varieties produce a short-to-medium vine and are the most satisfactory from the standpoint of easy harvesting. The vine of U. I. 15 is considerably more vigorous. U. I. 123 is most popular in southern Idaho. It, as well as U. I. 59 and 81, is grown in several other States, including Montana, Wyoming, and Nebraska. Two new Great Northern varieties U. I. No. 16 and U. I. 31 have recently been released by the Idaho Station. Both are resistant to a new strain

of common bean mosaic as well as to the regular bean mosaic and to curly top. The characteristics of these varieties are similar to those of Great Northern U. I. 15.

Red Mexican U. I. 3 and 34 have larger seeds than the common Red Mexican and are darker red in color. These new varieties have similar vine and pod characteristics, although U. I. 3 has a slightly heavier vine than U. I. 34.

Montana No. 1 is another mosaic-resistant Great Northern introduced by the Montana Agricultural Experiment Station. The seed is slightly smaller than U. I. 123 and the plants are less viny than the Idaho strains of Great Northern, being about 12 inches high. The pods are held upright on the plants and so are less likely to discolor and mold before they are harvested. Earliness is the outstanding characteristic of Montana No. 1. It matures from 7 to 10 days earlier than the Idaho strains and so it often escapes injury from early frosts.

The Pinto is grown in several irrigated areas. The strains grown under irrigation generally are not the same as those grown in non-irrigated areas. Several new strains have recently been released to growers. They are Pinto Nos. 5 and 14 introduced by the United States Department of Agriculture and Pinto U. I. 72, 78, and 111 introduced by the Idaho Agricultural Experiment Station.

Pinto Nos. 5 and 14 are resistant to rust, which is frequently widespread in the irrigated sections where the Pinto is grown. They resemble the commercial Pinto in most of the other characteristics. They are a little more viny than are the Idaho and Wyoming strains of Pinto, and the pods are a little longer. Their seed-coat pattern is practically the same as that of the commercial varieties except that it is somewhat brighter. The new varieties require about 96 days to reach maturity, about 7 days longer than the Idaho or Wyoming strains but about 10 days to 2 weeks less than the native Colorado strain.

Pinto U. I. 72, 78, and 111 are resistant to common bean mosaic and curly top. Their seeds are larger than the commercial Idaho Pinto and the plants are less viny than either the commercial strains or Pinto Nos. 5 and 14. They are relatively early in maturity, being about 1 week earlier than Pinto 5 and 14. U. I. 78 is somewhat earlier than the others. The Idaho strains have not been grown extensively enough to show whether they are well adapted to Colorado.

In Wyoming, the Golden Pinto, which originated near Riverton, is the most commonly grown strain. It is from 10 days to 2 weeks earlier than the old native strain. It is also widely grown in the irrigated sections of Colorado and is known there as the Wyoming Pinto.

Climate should be considered when a variety for any one area in California is chosen. Large Limas are favored by warm but not hot days, a fair amount of humidity, and no sudden changes in temperature between day and night. They are grown chiefly in southern California along the coast. Baby Limas do well under the warm-to-hot conditions in the Central Valley and interior valleys in southern California. They are grown throughout the San Joaquin Valley of California, and there is an extensive acreage in the Sacramento Valley. The Small White will stand higher temperatures than the Large Lima, but not as high as the Baby Lima; it is grown principally in the counties along the south-central coast. The Pinto is favored by a warm growing season and is grown mostly in the Sacramento Valley.

Pinks are favored by warm days and fairly warm nights such as are found in Monterey and Sutter Counties. The Red Kidney, Bayo, and Cranberry varieties are grown on river-bottom lands of the Yuba, Sutter, Sacramento, and San Joaquin Rivers in areas that are richly supplied with soil water.

A new strain of Pink, known as Sutter Pink, was recently developed by the University of California. It was derived from crossing Standard Pink and Early Pink. Its seed characteristics are like those for Pink beans but its vine is more vigorous than Early and less spreading than Standard Pink. It matures earlier than Standard Pink and yields better than Early Pink. It is particularly adapted to the Sacramento and San Joaquin Valleys.

Several new Blackeye varieties have been released by the University of California. These are California Blackeye 1, 5, and 7. Blackeye 1 has bright, white seed and is resistant to cowpea wilt, nematodes, and charcoal rot. Resistance to the rot makes it suitable for dryland farming where charcoal rot is likely to occur. Blackeye 5 has a seed somewhat larger than the regular California Blackeye but otherwise is similar. It is not so resistant to cowpea wilt and nematodes as Blackeye 1. It is the most extensively grown of the new strains. Blackeye 7 has bright white seeds. It is resistant to wilt and nematodes and so it is widely adapted.

PLANTING

DATES.—Safe dates for planting often vary somewhat within a State. An inexperienced grower or one who is not familiar with a local area will find it to his advantage to get seedtime recommendations from someone who is well acquainted with the area. In the Yellowstone Valley of Montana, May 20 to 25 is the recommended planting period above Billings, but the season is 5 to 10 days earlier on the Billings Bench, the other side of the city. In south-central Idaho nearly all of the beans are planted between May 20 and June 15. Depending partly upon the locality and the strains that are being planted, the seeding may be safely done from May 20 to June 20 in Nebraska, May 15 to June 15 in Colorado, and May 20 to June 1 in Wyoming. Recently, many growers have been seeding from June 10 to 20, in Nebraska, because they believe that later plantings are more likely to escape bacterial blight.

Seeding time in California varies from early April to July. Typical planting times for major varieties are as follows.

Standard Limas	April–June.
Baby Limas	May–June.
Small Whites	May 15–June.
Blackeyes	April–July 10.
Pinks and Mexican Reds	April 15–June 15.
Red Kidney, Bayos, and Cranberries	June 20–July 10.

RATES.—Rates of planting differ for different varieties and areas. Common seeding rates in Idaho are 90 to 100 pounds to the acre for Great Northern, Small Reds, and Pintos. The higher figure is recommended for contract-garden beans. Some growers plant even more than this. One reason for the relatively high seeding rates in Idaho is to assure a stand in years when curly top infestation is serious. The planting rate in Montana is lower, 35 to 40 pounds being common,

if harrowing is not done. This rate will give an excellent stand under Montana conditions, if germination is at least 95 percent. The rate should be increased to 50–55 pounds if the beans are to be harrowed. The seeding rate for Montana No. 1 is less because the seeds are smaller. Common rates in Colorado, Nebraska, and Wyoming are 40–60 pounds to the acre. In New Mexico about 40 pounds of Pinto to the acre is recommended. The rates per acre in California are about as follows:

80–100 pounds for Large Limas.
40 pounds for Baby Limas.
35 pounds for Small Whites.
20 pounds for Blackeyes.
35 pounds for Pinks.

METHODS.—After the land has been prepared, the beans are planted with various kinds of planters. The principal types used are regular bean and beet planters with four, six, and eight rows, grain drills, and two-row surface planters. Four-row planters are common in most areas (fig. 4), but the six-row is also common. The six- and eight-

FIGURE 4.—Planting beans with the commonly used four-row planter. Two-, six-, or eight-row planters are also used in many areas.

row implements are adapted to larger fields. Some growers remove the two outside units from the six-row drill when they use it in small fields. In areas that produce both beans and sugar beets the planters are usually sold complete with fertilizer attachment. In California, plate-type planters are generally used for beans other than Limas.

In areas that grow both beans and sugar beets, the two crops are often planted in rows of the same width—20 to 22 inches. This makes it easier to use the same planter and cultivator on both crops. Large Limas are commonly planted in 28- to 36-inch rows. The Baby Lima, Blackeye, and Small white are more common in 28- to 30-inch rows.

The seed should be covered from 1½ to 3 inches, depending on the type of soil. In some cases the seed is covered by as much as 4 inches. The recommendation in Montana is for not more than 1½ inches deep on loam soil that has plenty of moisture. In some areas a ridge cover

is thrown over the row to be harrowed off when the seeds have sprouted. The ridge aids the germination and the harrowing helps to control the weeds and breaks any crust that may have formed over the seed.

CULTIVATION

Weed control is the primary reason for cultivation. Weeds compete for both moisture and plant food and weed and grass roots may bring in considerable dirt during the harvest. Cultivation may begin before the beans are up, particularly if they are "irrigated-up" or if weeds appear. Harrowing, preferably before the beans are too near the surface, is used some. If the plant is too near the surface during the harrowing, it is likely to be broken. Some growers seed more beans per acre to allow for such breaking. Spike-tooth or spring-tooth harrows are generally used, but the "tickler", or weeder-tiller, and rotary weeders are now common in some places.

FIGURE 5.—Cultivating beans with a four-row cultivator adjustable to rows of various widths. Two-row and six-row implements are used in some areas.

The usual practice in Idaho is to begin cultivating soon after the beans are up, and continue as needed until the vines are large. Cultivation usually begins there around June 15 and is finished by about July 15; 4-row cultivators are used almost entirely. In 1938 most cultivating equipment was horse-drawn, but now a large part of it is tractor-drawn. Four-row cultivators (fig. 5), usually tractor-drawn, are more common in most irrigated areas, but six-row implements are also in use. On small farms or acreages one-row tractor-attachment cultivators are sometimes used. Various combinations of tools are used for cultivation. Bull tongues and duckfeet, or knives and duckfeet, are the usual tools. Bull tongues and disks are sometimes used. In the cultivation that comes before an irrigation, ditching shovels replace the duckfeet or bull tongues.

The first cultivation after the beans are up can be fairly deep. Knives set close to the plant, with the duckfoot or sweeps or other tool following between the rows, is the usual way. As the root system of the bean soon reaches near the surface and spreads from the main plant, the later cultivations should be shallower and farther from the plant. Three to five cultivations are usually enough but more may be needed on foul land. It is generally best not to cultivate after the plant starts to bloom. If cultivation at this stage is necessary, care must be taken to avoid damaging the root system and knocking off the delicate flowers.

At least one hoeing is usually needed to clean the weeds left by machine tillage. Thinning is sometimes done in connection with the hoeing job.

IRRIGATION

Beans are shallow-rooted and sensitive to an oversupply of water. Irrigations should be given whenever necessary to keep the plants in healthy growing condition but these irrigations should be light. Good moisture insures early maturity and high yields on a given soil. Heavy applications waste the water and, in some places, may cause excessive vine growth and delay the maturity. The number of irrigations and the amount of water needed for each irrigation depend partly on the season and the type and depth of soil and partly on the amount of organic matter in the soil and the slope of the land. A dry windy season calls for more water.

Most growers in Idaho irrigate three to six times after they plant, four being the most usual, but some irrigate as many as nine times. On the Twin Falls tract, 3½ to 4 acre-feet of water to the acre is used commonly on beans each year—less than on any other crop except peas. On the Salmon tract, where water supply is more limited, only 2 acre-feet or less to the acre is used on beans and other crops. If the water is used carefully and is not wasted, 2 acre-feet will produce a good crop of beans in this area if other conditions are good.

In California, one to three irrigations are common, distributed in furrows at the rate of 3 to 6 acre-inches, for each application. The usual number of applications in Colorado, Wyoming, Nebraska, and Montana is three to four. Fewer may be given in some instances and the range is up to six or seven. About 4 acre-inches for an irrigation is common in Colorado.

An ideal field for irrigation is one which has a smooth gentle slope. Almost any land can be irrigated but more or less leveling and floating is essential to good irrigation. In addition, the land should be furrowed uniformly, so water will not stand in the furrows. And the furrows should be deep enough to prevent flooding and to keep vines out of the water. Water standing in the furrows or flooding over them will reduce yields. Nearly all growers in southern Idaho irrigate between every other row (fig. 6). In the sandy loam soils of western Nebraska irrigation in every row is desirable because the water spreads slowly in a lateral direction.

A good time to apply water is just before the plant starts to bloom. This helps to get a good set of beans. A moderate application soon after the pods are set and perhaps another a little later, to help them fill well, is generally recommended. Many growers plan the last irrigation as late as when the first pods begin to turn. This late

FIGURE 6.—Irrigating a 100-acre field of beans near Twin Falls, Idaho, the water being diverted into furrows by means of a stilling pool. Irrigating between every other row is common here as well as in several other States.

irrigation is intended to hasten the filling and maturing of the last pods set but such late watering in some cases may cause excess vine growth and delay the ripening until danger of frost. In all cases the water should be allowed to run only as long as is necessary to wet the soil to capacity in the root zone. In fields of long rows and where there is not much slopse a cross ditch should be made at about the center of the field. Otherwise the upper end is likely to be flooded before the lower end is wet.

HARVESTING

Harvesttime is a critical period for dry beans. Loss of beans and a reduced quality may result from improper timing and methods of handling. Beans may be damaged if left in the field too long before being cut but even greater losses may occur while the crop is curing in windrows or bunches.

The pulling or cutting should begin when most of the pods have turned yellow and before they have dried. If the pods are allowed to become too dry, they will shatter. A few days' delay in harvest may mean a heavy loss, particularly if the beans are not handled in early mornings when the pods are tough. Although some beans are cut with knives attached to sleds and cultivators, regular 2- and 4-row bean cutters are in more general use (fig. 7). The cutting may be preceded by a vine splitter, particularly in the case of Blackeye beans. Four-row tractor attachments are the most common. In fact, four-row cutters are about the only new ones sold in some areas, as enough farmers have two-row equipment or can buy used equipment. Some cutters have a special rake attachment for gathering beans into bunches. In areas that are too trashy or weedy for the successful use of the buncher, the beans may be bunched by hand.

FIGURE 7.—Cutting beans near Puente, Calif., with a four-row bean harvester, which leaves the beans in a neat windrow behind the tractor. Some growers attach a side-delivery rake to the tractor and so cut and rake at the same time.

FIGURE 8.—Windrowing beans with a side-delivery rake before they are threshed. Some growers use a mechanical buncher instead of a rake, attaching it to the rear of the tractor so the beans can be bunched when they are being cut.

Both two- and four-row cutters are equipped to put each pair of rows into windrows. Side-delivery rakes are used to combine two

or more of these double rows (fig. 8). The beans may be left in the windrow or for a pick-up combine or a loader, if the beans are to be threshed with a stationary thresher, but hand bunching is general in some areas, including Montana, Colorado, and parts of California, even though more labor per acre is required than by other methods.

In Colorado the vines are collected in small, rather flat bunches that can be turned over easily with a pitchfork for rapid curing and drying in case rains come. Bunches are less likely to be scattered by high winds than windrows, which have a tendency to roll. Proper care in curing reduces the number of discolored beans.

If it is uncertain when a thresher or combine will be available, it may be well to stack the cured beans. This prevents blowing and reduces shattering and losses from rain. Better quality and larger yields of beans may more than offset the increased labor and its costs. Another advantage of stacking is that fall-seeded crops may be planted at the proper time or the land may be listed or otherwise roughened to prevent blowing, but stacking is the exception rather than the rule in most western areas.

Pick-up combines are used more and more. Small machines, 4, 5, and 6 feet, are common. It is estimated that more than 90 percent of the beans in south-central Idaho are now threshed with combines, compared with about 60 percent 9 years ago. In 1943 about 72 percent of the Idaho crop was harvested with the combine, which picks up from either bunch or windrow. Usually only a small acreage is combined from the standing crop but in 1943 considerable acreages in Nebraska and Wyoming were so harvested (table 2).

TABLE 2.—*Harvesting method and custom-harvest rates, by principal producing States, 1943*

State	Acreage harvested, 1943	Percentage of acreage that was—			Custom rate for—	
		Combined		Threshed with stationary threshers and hullers	Combining per acre	Threshing per bushel
		From standing crop	From windrow, bunch, or pile			
	1,000 acres	*Percent*	*Percent*	*Percent*	*Dollars*	*Cents*
New York	113	1. 6	4. 4	94. 0	3. 90	13. 2
Michigan	617	. 2	26. 3	73. 5	3. 60	12. 0
Nebraska	80	23. 8	52. 1	24. 1	3. 30	22. 0
Montana	62	1. 0	28. 0	71. 0	3. 40	14. 1
Idaho	168	. 6	71. 4	28. 0	6. 50	17. 0
Wyoming	112	10. 0	25. 0	65. 0	4. 10	14. 8
Colorado	507		42. 0	58. 0	3. 60	21. 2
New Mexico	240		37. 4	62. 6	2. 50	22. 0
California [1]	442	(2)	90. 6	9. 4	7. 40	31. 3
Other States	63	20. 0	32. 0	48. 0	5. 10	22. 5
United States	2, 404	1. 9	45. 7	52. 4	5. 20	16. 3

[1] For California, all data except acreage harvested refer to the 1944 crop.

[2] Information on the combine and threshing method was not available but it was estimated that relatively few beans were combined from standing crop or threshed from the stack or barn.

Engebretson, T. O., and Carpenter, C. G. Harvesting Dry Edible Beans, USDA, March 1946. [Processed.]

Regular bean threshers are largely used in some areas. One machine may serve many farms or many acres. These machines do an excellent job, but an investment in one of them is not justified on most farms. They are generally owned by contractors or by farmers who do custom work besides harvesting their own crop.

Beans require slow and careful threshing. The vines are often dirty and the rather large bean seeds are likely to crack or split if handled roughly. It is fairly easy to adjust ordinary threshers and combines so they will handle beans satisfactorily. If a threshing machine of an older model is used, all but one row of the concave teeth and half of the cylinder teeth should be removed. Some modern threshers have rubber-faced cylinder bars and have concaves without teeth. Cylinder speed should be reduced to 270 to 400 revolutions a minute and the lower speeds used when the larger varieties of beans are threshed. The rest of the separator should be operated at ordinary speed for good clean threshing.

If the combine is to be used, special attention should be given to the number of rows to be raked into one windrow. The size of the windrow depends mostly on the size of the combine to be used in threshing. A fairly safe rule is to limit the windrow to the number of rows that would about equal the width of the cutter bar—or the number of plants that could be grown on ground the same width as the cutter bar. If rain falls while the beans are in the windrow they should be turned and should not be allowed to lie for long on the wet ground, as they absorb moisture and may become discolored and may even germinate.

The combine should have cylinder speed and concave adjustments similar to those for threshing machines. According to Farmers' Bulletin 1761, Harvesting With Combines, usually, edible beans can be threshed with a cylinder running at from 50 to 70 percent under normal. With such a low speed, it is often necessary to employ all of the concave teeth to do satisfactory work. As is the case with soybeans, care should be exercised in providing sufficient lateral clearance between cylinder teeth and conclave teeth in order to minimize cracking the beans. The adjustment made for starting the machine in the morning, if the bean pods are damp, will doubtless need to be changed later in the day when the pods have dried out. In adjusting for close threshing no attempt should be made to save the green, immature beans, for in so doing an adjustment may be necessary which would result in considerable splitting of the dry, mature beans. No special sieves are necessary for combining beans. The same ones used in small-grain threshing are found satisfactory.

Attachments are available for most threshing machines and combines for the threshing of beans and similar crops where low cylinder speeds are desirable to avoid excessive cracking of the seed. They are available in several different speed combinations. They include change-over parts to get the proper speed of the cylinder and other parts of the machine, and changes in concaves and screen equipment. Other special equipment for combines include pick-up attachments, devices for deflecting straw into windrows or piles, straw spreaders, and special bagging platforms and equipment.

NONIRRIGATED AREAS

About half the dry-bean acreage and a fifth of the production in the Western States is on nonirrigated land, mostly on dry land in New Mexico, Colorado, and California (table 1). Some is in areas that have more rainfall, notably in the coast area of southern California and along the warm high ridges in northern Idaho where excellent air drainage is provided by the deep canyons.

Beans are an important dry-land crop in several areas where wind erosion is serious. The erosion is greater on bean land unless proper precautions or control measures are taken.

PLACE IN THE CROPPING SYSTEM

In the dry-land areas of the Great Plains beans compete mainly with corn, feed crops, and fallow. Wheat has first call on the land. Beans are often grown on dry land as a substitute for fallow, and they may be harvested in time to permit seeding winter wheat or other small grains. They may be used also as a catch crop for corn and on abandoned wheat land.

In the Estancia Valley area of New Mexico, beans are a major crop along with corn, wheat, and sorghums. They have first consideration and furnish a main part of the income on many of the farms. But even on these specialized farms, they generally should not be planted on more than 60 percent of the cropland. Feed enough to support a few milk cows, chickens, hogs, and—on the larger farms—a few beef cows should be grown besides.

Most farmers in the dry-land bean areas of the Great Plains and the Southwest have to conserve moisture and reduce losses from wind erosion. Soil blowing will do much damage after the bean crop is harvested unless preventive measures are taken. One means of holding down erosion is growing beans in alternate strips with sorghum or other crops which leave a good anchoring stubble. Colorado Agricultural Experiment Station Bulletin No. 482, Field Bean Production Without Irrigation in Colorado, recommends that the strips be at right angles to the direction of the prevailing winter and spring winds of the region. The physical nature of the surface soil determines the widths of the strips of beans and alternating crops. In Colorado the strips are from 1½ to 6 rods wide.

Another method of reducing soil erosion is to keep the surface rough after harvest—this in addition to strip cropping. Bean land after harvest is loose and pulverized and so is susceptible to severe wind erosion. Working deeply with the lister, duckfoot, or field cultivator is recommended immediately after the crop is harvested. Another method used by many farmers is to plant the bean land immediately after harvest to wheat, rye, winter barley, or oats. This may be done with a seeding attachment on the bean puller.

Terracing is advisable in some areas to prevent erosion from torrential rains. Terracing and working the land on the contour also conserve moisture and in years when moisture is scarce this should help to get higher yields.

In the northern Idaho bean-growing area either biennial sweetclover, alsike clover, or alfalfa is recommended in the rotation with wheat and beans to maintain soil organic matter. Sweetclover once in 4 years is generally enough for this purpose. It is used as a green

manure and provides some pasture or hay. It may be seeded with a small grain early in the spring. The grain is harvested in the usual way and the next year the clover may furnish some hay or pasture before it is plowed under as green manure.

Where alfalfa is the soil-improving crop the land is devoted to the production of alfalfa continuously for four or more years and then to the growing of beans and wheat.

Alsike clover, if grown both for improving the soil and for feed, is a very satisfactory crop for the more humid part of the bean-growing districts of northern Idaho. The clover is planted with small grain in the early spring and is then used for one or more years for seed production, provided, of course, a satisfactory stand is obtained. After the clover is plowed up, the land is used for the production of beans, wheat, and other crops for two to four years before beans are grown again.

PREPARING THE LAND

Preparing the seedbed and planting and cultivating beans are very similar to the same operations for corn and sorghums. The same farm machinery is used for all of these crops.

Soil moisture is very important if a good bean crop is to be grown in dry-land areas. Small-grain land generally should be worked in early spring and kept free of weeds up to planting time. The Colorado station says that later spring workings on stubble land should aim to destroy weeds and to keep the surface open and receptive, preferably pock-marked, to trap any hardbeating rains. Rainfall the last of April and through May is likely to be torrential, and subject to heavy run-off from all smooth surfaces.

In Colorado and Nebraska when beans follow small grains or row crops other than beans it is common to plow early in the spring and disk one to three times before planting. Some farmers disk and then blank-list before planting. n fields where beans follow beans, blank-listing in the fall to help control soil blowing is usual. If this is done the land may be re-listed or worked with a disk cultivator and harrow before it is planted.

The Colorado Agricultural Station, quoted above, recommends that row-crop land should also be early springworked, not later than when the first weeds start, and kept free of weeds and in the best surface condition to trap rainfall up to planting time. Sometimes such stubble land, especially when the row crop has been harvested close to the ground, will present a wind-erosion problem and actually start to blow. In such cases, the seedbed culture for the next crop should be in the fall, or when the blowing starts, and of such nature as to up-end the root clumps. The duckfoot or field cultivator is an excellent implement for such jobs. The disk in such cases may give temporary relief, but it pulverizes the soil and may leave it in a condition favorable for blowing.

The lister is also used effectively for this purpose. In the Estancia Valley area blank-listing every other row in the fall and relisting in the spring is the most common practice.

Methods and equipment used in land preparation in California are those used generally for other row crops grown in the State. Subsoilers or moldboard plows are used in the autumn to roughen the soil. This helps to retain winter rainfall. Spring tillage is directed toward preparing a good row-crop type of seedbed. Special

equipment—including chisels, Swede harrows, cyclones, and clod mashers—are used in the final work.

In northern Idaho some growers plow in the spring and some in the fall. The rush of spring work on many farms makes it advisable to do considerable plowing in the fall as soon as the soil is moist enough to be worked. Fall-plowed land should be left rough until spring. The land is usually double-disked twice in the spring and harrowed twice before the planting. This is done mainly to destroy weeds and to prepare the seedbed. More than two, or less than two, may be advisable. Spring-tooth harrows and rollers are also used there.

A thorough preparation of the seedbed leaves the soil in good tilth, destroys most of the weeds, and materially lessens the number of cultivations that will be necessary after the beans are planted.

VARIETIES

The specific varieties recommended vary somewhat according to areas. The Pinto is the best adapted variety of field bean for the Great Plains and for the dry-land bean areas in the Southwest. It is one of the large group known as Mexican beans. Colorado and New Mexico, in that order, have the main dry-land Pinto areas, but large quantities on either dry or irrigated land are grown in several other States. Within the last few years several new Pinto varieties adapted to dry lands have been developed and are recommended for different areas. These are: (1) Scotts Bluff Pinto, (2) San Juan Pinto, (3) New Mexico Pinto No. 295 and No. 641.

The Scotts Bluff Pinto was introduced by the Nebraska Agricultural Experimental Station and is a selection from a cross between Great Northern and the common Pinto bean. It is particularly adapted to conditions in western Nebraska. It is like the common Pinto except that it is about a week or 10 days earlier and so is less likely to be damaged by early frosts.

The San Juan Pinto was selected from the native Colorado Pinto by the Colorado Agricultural Experiment Station and is particularly well adapted to southwestern Colorado. It is more uniform, yields better, and appears to be more tolerant to common bean mosaic than the old Colorado strain.

New Mexico Pinto Nos. 295 and 641 are also selections from the native Pinto and have characteristics that particularly adapt them to New Mexico conditions. Both strains are somewhat earlier than the old type although Pinto No. 641 matures slightly earlier than No. 295 and is recommended for the northern part of the State. Pinto No. 295 is recommended for the middle and southern parts. Neither is disease resistant.

Small white flat beans are the most popular type in northern Idaho, but other varieties are also grown there. During the war particularly, Great Northern, Red Mexican, and Pinto beans were grown there.

About a fifth of the average annual production of beans in California consists of Standard Lima. The Ventura variety of Standard Lima, developed by the California Experiment Station, occupies most of the acreage. This type of bean requires a fairly humid, moderate climate without sudden changes between day and night temperatures. The Standard Lima is grown only in a narrow belt of land 8 to 10 miles wide along the coast of southern California. More than half

the acreage usually is on irrigated land. Baby Lima, second largest in prewar volume of production in California, is grown almost exclusively on irrigated land. Production of Baby Limas has reached first place since 1944; they now form more than 30 percent of the total crop in California. The major commercial variety (Wilbur) of Baby Limas, is being rapidly replaced by Westan, a variety that is resistant to rootknot nematodes. It was developed by the California Experiment Station. Only a small part of the Small White, which is grown mostly in California, is grown on nonirrigated land. The main Small White variety is Small White 38, a mosaic-resistant variety produced by the California Experiment Station. It is grown in the cool humid parts of the central coast region.

The Pink, the Blackeye, and the Mexican Red are widely distributed in California because of their wide range of adaptation. The Pink is raised mostly under irrigation in all bean districts of the State. Little, if any, is grown outside California. The Blackeye is more tolerant to heat and drought than the other varieties grown in California. But it is sensitive to cool weather and reacts unfavorably to the coastal climates, so the bulk of the Blackeye acreage is located, under irrigation, in interior valleys. The Small Red (Mexican Red) is adapted to about the same areas as the Pink, excluding southern California. Before 1926, California produced practically the entire United States supply of Small Reds. Since then, the California acreage of this bean has retracted, mainly because of low prices compared with prices of other beans. Idaho is now the principal Small Red producing State (on irrigated land).

PLANTING

DATES.—Beans are a warm-season crop. They should be planted only after the soil is warm and danger of frost is past and they should be planted in a weed-free seedbed. The best time to plant varies by areas, by availability of moisture, by altitude, and with early or late seasons. The following schedule is a good guide to safe planting dates in selected dry-land areas:

Montana	May 20 to 25.	New Mexico	May 15 to July 1.
Wyoming	May 20 to June 1.	California	April 10 to July 1.
Colorado	May 20 to June 15.	Idaho	May 20 to June 10.
Nebraska	May 15 to June 15.		

Planting time varies appreciably within most States. For example, the best time at Akron Station in Colorado which has an altitude of 4,500-feet is June 10 to 20. July 1 is too late at this station. Slightly later plantings are advisable at lower altitudes and farther south. In higher altitudes the dates are narrowed by frost danger in both spring and fall.

RATES.—The best rate of seeding beans depends on the amount of available moisture, size of seed, germination percentage, relative freedom from weeds, and variety of bean. Common rates range from 8 to 10 pounds in Montana in 36- to 42-inch rows, to 15 to 25 pounds in 40- to 42-inch rows in Colorado, and around 18 pounds to the acre in 38- to 40-inch rows in New Mexico. Replanting is often necessary. Poor stands, damage from wind and hail, or other causes occasionally make it necessary to replant large acreages in some States. Lima beans in California are planted in 28- to 32-inch rows, depending upon the type and variety. The Standard Lima is planted at the rate of

50 to 80 pounds to the acre, in 30- to 32-inch rows. Baby Limas are planted in 28- to 30-inch rows, depending on the variety, at the rate of 20 to 30 pounds per acre.

METHODS.—The lister planter is most commonly used for planting beans in the dry-land areas of Colorado and New Mexico. A regular bean seed plate should be used instead of corn plates. If the land is free from weeds and in good condition, listing and planting in one operation is satisfactory. This method of planting helps to prevent soil blowing. Two- and four-row planters are most common. Some surface planting with furrow openers is done in the Great Plains, and some checkrow planting is done but it is not common.

In northern Idaho practically all growers use the ordinary grain drill, after plugging the holes that are not needed for beans. Two or three drills are often pulled behind one tractor. The old double-row bean or corn planter is used only a little.

Planting is generally done with four- and eight-row "Ventura" sprocket or cup-drop planters in the Lima bean areas of California. Plate-type planters are unsatisfactory for Limas because of the susceptibility of the large seed to mechanical injury, but they are generally used for other kinds of beans. A four-row planter pulled by a light row-crop tractor requiring one man in addition to the tractor driver will plant about 20 to 25 acres in a 10-hour day on level or slightly sloping ground. An eight-row planter, requiring one man in addition to the tractor driver, will plant 35 to 45 acres per day. The eight-row planter is used more than the four-row for planting Baby Limas.

Beans should be covered 1 to 2½ inches, depending on the type of soil and moisture conditions. They should be covered even up to 4 inches in some sandy areas.

CULTIVATION

Cultivation is done principally to keep out weeds, which compete for moisture, light, and plant food, and to prevent crusts on the soil, which are detrimental to beans. Controlling weeds is tremendously important in areas of low rainfall where the moisture is barely adequate for one crop. Cultivation also fills in the furrows, which makes easier the cutting or pulling.

Three cultivations are usually enough. Often one will do, if plantings are late. Occasionally four are needed. As killing weeds is the chief aim, the number of cultivations depends on the previous crop, the condition of the soil, the differences in amounts and time of rainfall, and the kind of machinery used. It is generally advisable to stop cultivation when the plants are large enough to "shade out" weeds or when cultivation would be likely to damage the roots.

Deep cultivation is not advised. It means an unnecessary loss of moisture and is likely to injure the shallow-rooted plant, particularly after the plant is 3 to 4 inches high. Cultivation should be as shallow as possible and still control the weeds. It is desirable to cultivate while the weeds are small. If weed growth starts on the sides of furrows in listed beans an "out" cultivation with disk cultivator or "go-dig," or a "knifing," may be given, even before the beans are up. Harrowing or rotary hoeing soon after the planting is one good way to control weeds in the row.

In the Estancia Valley the first cultivations are usually done with a knife sled. The second and third are done with a duckfoot cultivator. In the Great Plains it is common to harrow at least once, either before or soon after the first cultivation. Except where the beans were surface-planted, disk cultivators, or "go-digs," are also commonly used for the first two cultivations.

Four-row bean cultivators are generally used in northern Idaho, where two cultivations are often enough. Some growers there cultivate three times and some only once. Four-row and frequently 8-row cultivators, mostly tractor attachments, are used in California. Approximately 30 acres can be covered in a day with an implement of this size, except for the first cultivation, when the rate should be about 25 acres. Two to four cultivations are common. In California at least one hoeing by hand is usually necessary to remove weeds within the rows.

Hand weeding and hoeing should not be necessary in the Great Plains if the cultivation is careful and timely. But weeds may get a head start, so many growers find it desirable to hoe the crop once.

HARVESTING

If there is adequate moisture in the soil, beans tend to set pods until the first killing frost in the fall. This makes a harvest problem. If they are allowed to stand until frost, particularly if the first frost is severe, the seed may be damaged. Frozen immature beans are almost impossible to separate out in the threshing, but unfrosted immature seed will shrink in drying, and may be separated; so it is advisable to harvest before frost comes.

Beans are ready for harvest when some of the pods are dry and when most of them have turned yellow. The nearly mature beans will continue to ripen after they are cut. Too many dry pods will mean heavy shattering when the beans are harvested.

A small part of the dry-bean crop is harvested by hand, either by pulling or cutting with a shovel, and bunching with a pitchfork. Some growers bunch by hand after the beans are cut, but this is not common in all areas.

Regular mechanical cutters, either horse or tractor-drawn with guard rods for windrowing to center of two rows, are generally available and in common use, but often listers and cultivators with blades attached are used for cutting the beans. Four-row cutters, tractor attachments, are used in some areas. Either a mechanical piler or side-delivery rake, in addition to the cutter, is sometimes attached to the tractor (fig. 9). In Estancia Valley bean cutters and pilers are common, but on some farms side-delivery rakes are used to windrow beans, six rows, before harvesting with a combine. Small five- and six-foot combines (fig. 10) with pick-up attachment, which handle beans from either the windrow or pile, are common in this and in many other areas. These machines came into general use during the war when labor was scarce. The combine is more widely used in California, Nebraska, and Colorado. More than a fifth of the 1943 acreage in Nebraska was combined from the standing crop and more than half from the windrow, bunch, or pile (table 2).

Harvesting in California begins the latter part of August and continues into early November. There maturity is induced by the exhaustion of soil moisture—a result of the long rain-free summer

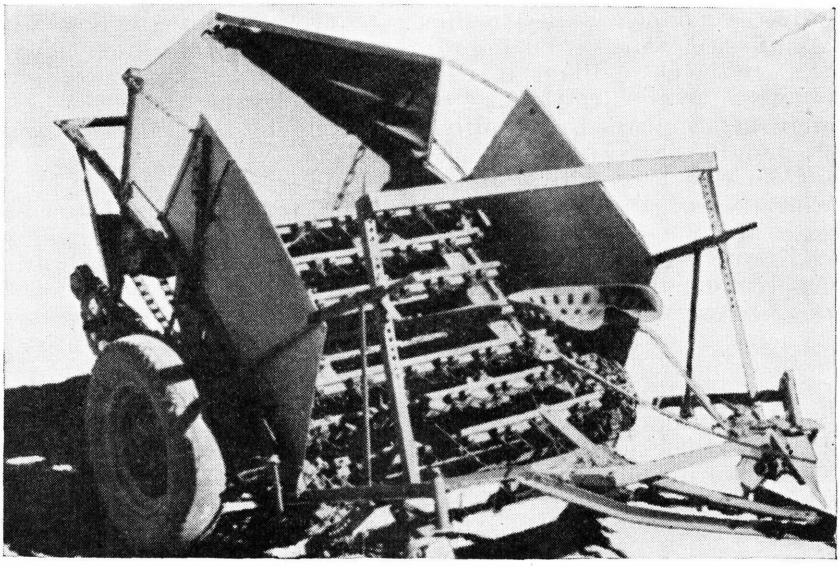

FIGURE 9.—Mechanical buncher in southwestern Colorado operated behind the tractor and cutter attachment. These machines are used in nonirrigated areas. One man drives the tractor and operates the cutter and buncher.

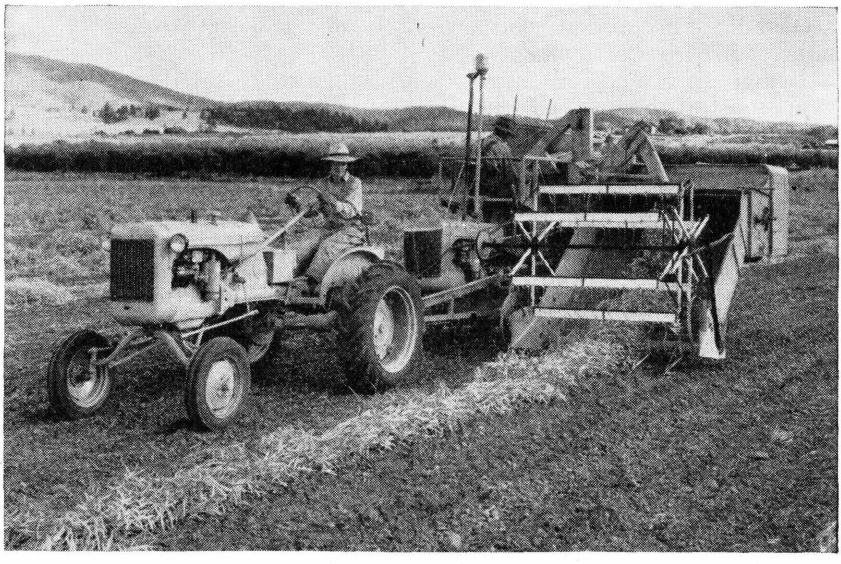

FIGURE 10.—Harvesting beans from the windrow in Oregon. In this field the straw is left in piles behind the combine.

climate. Four-row cutters, tractor-drawn or tractor-mounted, generally without spreaders, except on Blackeyes, are used in cutting the roots about 2 inches beneath the surface of the ground. Three to five acres can be cut in an hour. Generally, cutting is in early morning while the vines are moist and the beans do not shatter. The common

use of the pick-up thresher in both irrigated and nonirrigated areas has brought about the universal use of mechanical cutters and windrow curing, even with Large Limas, except in steep fields. A side-delivery rake or windrower may follow the cutter immediately. Sometimes it is attached to the tractor along with the cutter. Six to eight rows are generally placed in one windrow. Lima beans in fields that are too steep for side-delivery rakes, pick-up loaders, and pick-up combines, are usually piled by hand. Piling 3 to 4 acres by hand is a good days' work for one man. After being thoroughly dried in the field, which requires from 2 to 3 weeks, Limas are ready for threshing. Of all types of beans, Standard Limas are the most difficult to thresh without cracking or splitting.

The outmoded stationary "Ventura" type of thresher with its retinue of 10 to 20 horse-drawn wagons, requiring from 30 to 60 men for loading, hauling, threshing, etc., has almost disappeared. It has been replaced by a thresher that is pulled by a crawler-tractor; it has three cylinders, is of the pick-up type, is mounted on rubber tires, is custom-built, and is powered by a 50 to 75 HP gasoline engine. Most of these machines are made by one company in California. They use a five-man crew, which consists of:

One man, tractor driver.
One man, separator or machine operator.
Two men, sack sewers.
One man, sack jig or filler.

The beans are picked up in the field, from dumps of 5 to 10 bags, by a truck crew of 2 or 3 men using the mechanical sack loaders. Bulk handling of all except Large Limas is now rather usual. When beans are handled in bulk, 3 fewer men are used on the pick-up thresher and 1 man takes the place of the truck crew—he is the driver—but 2 or 3 trucks are needed for each thresher. The capacity of the pick-up thresher is from 800 to 1,300 bags (100 pounds) a day.

The bulk of the California bean acreage is grown on farms large enough to justify farmer-ownership of threshing units. These farmer-owners often will thresh beans on a custom basis for neighbors after they finish their own harvest. Even smaller farms are now owning the outfits as they help to meet the situation of labor.

The seed-bean industry is now using a machine that has been improved through experiments made by the University of California. Rubber rolls have been substituted for two of the three cylinders. Through this and other changes the mechanical injury to the beans has been substantially reduced. This thresher is used mostly in the threshing of seed beans of the following types: Red Kidney, Small Limas, Fordhook Limas, and various snap beans. It is not used in the Standard Limas, which are more difficult to thresh.

Baby Limas are usually combined from the windrow. Either small-grain combines or a special bean combine is used. The earlier special bean combines had one or two cylinders but the newer models have three. The special bean combine is also used for threshing other types of beans.

Beans can be either sacked or handled in bulk, with these machines. The price of the newer models was from $4,000 to $8,000 in 1943. More and more growers, particularly in the northern part of the area, handle the crop in bulk to the warehouse, except for the part that is intended for seed. The rate of performance for a large bean combine is from

800 to 1,300 sacks a day. Thirty-five acres with an average yield of 20 sacks to an acre can be threshed readily by operating the combine from 9 o'clock in the morning until 10 or 11 o'clock at night with 1 hour each for dinner and supper.

MARKETING, CLEANING, AND GRADING

Some beans are stored on the farm and then hauled later at perhaps a more convenient time. This is more common in Michigan and New York, where beans are relatively a smaller crop on the farm than in many of the western areas. In the West, the bulk of the crop is moved directly from the field to the local warehouse or elevator. Generally it is not economical to store beans on the farm. Part of the crop in some areas is hauled to the elevator by the local buyer. The cost of farm storage or the warehouse charges are low enough to permit growers who are in a financial position to do so to hold their beans until the market suits them. A western grower usually sells his beans in the warehouse after they have been cleaned and graded. The sale price is agreed upon between the grower and the buyer, who often is the warehouseman. In California, the bulk of the Lima and Red Kidney crop is marketed through bean growers' associations. The remainder of these two types and other beans are marketed through dealers, country buyers, or brokers.

Most seed beans of the garden varieties are grown under contract. Formerly other beans were generally grown without a definite indication of the selling price, but this has not been true during the Federal price-support program since 1942.

Thresher-run beans may contain trash, broken and discolored beans, and small stones. They often grade U. S. Substandard because of large quantities of such foreign materials. So beans must be cleaned and graded if a clean, high-grade, uniform product is to be marketed. Proper cleaning requires special equipment. Rubber rollers which crush clods of soil that would not otherwise be removed except by hand picking, are an important feature of this equipment.

Cleaning and grading are almost always done at the "bean house." In areas where the selling price is based on cleaned and graded beans, a grower is charged for cleaning, bagging, handling, storage, and insurance. Some States, Idaho and California for example, have relatively favorable public warehousing laws which encourage the growers to use public cleaning and storage facilities. In 1946, Idaho growers paid 60 cents per hundredweight for cleaning, grading, and sacking, including the cost of the bag. The warehouse charge was ½ cent a bag after the first 30 days, which were free.

Some beans are delivered to the warehouse in bulk and others in sacks. After being cleaned and bagged, they are inspected and graded according to the specifications of the United States Department of Agriculture. In the West the cull beans are either returned to the grower for livestock feed or sold to feeders or to feed dealers. During the recent war years most of the split beans were reprocessed for human use.

Hand-picked beans are in demand, particularly for canning and for sale in consumer-size packages. Some hand picking is usually necessary to remove discolored beans, pebbles, and other foreign material not removed by the machine cleaning process. However, the electric-

eye sorting machines are rapidly displacing this hand labor, particularly for white beans. A few processing plants have been modernized so that the beans of 99 percent purity or better "not touched by human hands" can now be sold in consumer-size packages or in 100-pound bags for canning or wholesale trade. These operations are almost entirely mechanical.

The United States Standards for Beans, published by the Department of Agriculture, defines grades for beans. The top grade for any one of the classes, except Pintos, Limas, and mixed beans, is designated "U. S. Choice Hand-Picked." The top grade for Lima and Baby Lima is "U. S. Extra Number 1." Respective grades for Pinto beans allow a greater percentage of total defects than do corresponding grades of other classes. The principal U. S. grades are:

All Beans Except Limas and Baby Limas:
- U. S. Number 1.
- U. S. Number 2.
- U. S. Number 3.
- U. S. Substandard.
- U. S. Sample.

Limas and Baby Limas:
- U. S. Extra Number 1.
- U. S. Number 1.
- U. S. Number 2.
- U. S. Substandard.
- U. S. Sample.

INVESTMENT IN FARM MACHINERY

As practically all equipment used in growing dry beans is used with other crops, relatively little of the investment in machinery is chargeable entirely to beans. This is not true on farms where special bean combines or bean threshers are used. On most farms there is a small investment in a bean cutter. The retail price of the tractor-attachment cutter for beans, in late 1946, ranged from $115 to $165 in Idaho, varying largely with the type and make of tractor. Local price quotations in Idaho in 1946 for other major equipment were about as follows:

15-foot weeder tiller (tickler)	$80
4-row cultivator	$160–200
4-row planter	$150–165

A good indication of the investment cost of major items of equipment used in the production of dry beans and other crops on irrigated land in Montana is shown in table 3.

In the Billings bean area the planters are commonly sold with a phosphate attachment for use on sugar beets. The 1946 prices, including this attachment, were $390 for the four-row and $510 for the six-row planter.

IMPROVING THE CROP BY SEED SELECTION

Only seed of high quality should be used. Equally important is the use of disease-free seed and disease-resistant varieties. So it is often necessary for the grower to buy seed that has been grown outside his State or area. Many other growers find it more practical and convenient to buy their seed beans. Some agricultural experiment stations are a source of improved varieties for the industry through their plant-breeding and seed-improvement programs. These often are more effective in maintaining purity, yields, and resistance to disease than is a farmer-operated program but some farmers do a good job of producing high-quality seed for their commercial crop of beans.

TABLE 3.—*Major items of equipment for irrigated bean farms and their cost in Montana, 1946*

Equipment	Description	Retail prices (late 1946)	
		Smaller equipment	Larger equipment
Plow	Single-bottom, 2-way, 16-inch	$210	
	2-bottom, 2-way, 14-inch		$350
	2-bottom, 2-way, 16-inch		[1] 360
Harrow	Spike-tooth, steel drawbar, 3-section	70	70
Disk	8-foot tandem	200	200
Leveler	14-foot	280	
Do	16-foot		340
Ditcher	Double-wing	155	155
Planter	4-row	340	
Do	6-row		430
Cultivator	4-row attachment without tools	105	
	Tools for beans	60	
	6-row attachment without tools		190
	Tools for beans		85
Harvester	4-row tractor attachment	110	
Do	6-row tractor attachment		160
Side-delivery rake	4-bar type	220	220
Wagon and rack	Rubber tires	300	300
Hand forks	4 forks	8	8
Thresher	With bean attachment 22-inch	1, 600	1, 600
Combine	With pick-up attachment, 5-foot	[1] 1, 200	[1] 1, 200
Tractor	Rubber tires, starter, and lights, 4-row	975	
	Rubber tires, starter, and lights:		
	6-row		1, 500
	6-row		[1] 1, 800
Total		4, 633	5, 608

[1] Not in total.

Wide variation in the individual plants will be observed in a field of maturing beans. Some of the plants are mature; others are still green. Some are heavily laden with well-filled pods; others have only a small number of seeds. By careful seed selection the crop can be greatly improved and this variation decreased. Such selection aims to increase the yield and vitality of the seed, improve its quality, and produce plants that will ripen evenly. In some localities it is desirable to select early maturing plants so as to shorten the time required for maturing the seed. Permanent results cannot be obtained unless such selection is done every year, for bean plants have a strong tendency to return to their original type.

A practical method of seed improvement used by successful bean growers is as follows: Select a large number of plants heavily laden with ripe pods from the field. Take them from parts of the field where the stand is uniform and from soil representative of the general soil conditions. Do not select plants from outside rows or from poor stands.

Pull the plants by hand, remove them from the field, and carefully inspect them to obtain the best 25, 50, or 100. Thresh them individu-

ally, and place the beans from each plant in a separate, numbered paper bag.

The next year plant these selected seeds by hand, the contents of each paper bag in a separate row. The grower will see at harvest-time that in many cases he did not "know beans." A number of rows will be found to have produced progeny distinctly inferior in some respect. Here the advantage of having the progeny rows will be apparent, for the bad rows can be discarded entirely. If the seed had not been planted this way it would be practically impossible to remove the poorer types of plants by roguing. One or more rows will be found to be decidedly better than the rest. All the seed from these good rows should be saved for next year's seed plot. After the beans from a few rows which may be distinctly poor have been discarded, seed from the rest of the plot can be used to plant the field.

After a year of individual selection a strain can be established which can be kept fairly pure by discarding all the inferior plants from the seed plot. Each year the plot should be sown and should be large enough to furnish all the planting seed needed. The extra labor in threshing that this selection plan calls for comes at a time of year when it can be spared as it is possible to store the selected plants unthreshed for a while. The greater producing value of the selected strain of beans will richly repay the extra labor of hand planting.

INOCULATION

The artificial inoculation of bean seed with nitrogen-fixing bacteria is generally unnecessary. Tests in New York and Michigan do not indicate that bean growers, on either new or old bean soil, would be justified in doing it but in some of the Western States inoculation of seed for areas that have not been previously cropped to beans is recommended.

USING THE STRAW

It is estimated that more than 60 percent of the straw from dry edible beans in the United States was saved for feed, for bedding, or for sale, in 1943. Of the total straw, about 5 percent was bailed, about 57 percent was used as loose straw, and the rest was left in the field and in most cases plowed under. About 25 percent of the bean straw in New Mexico and about 10 percent in California was baled. In most States the main part is used as loose straw. In California (where 90 percent of the bean acreage was combined) more than 85 percent of the straw was spread on the fields by the threshers to aid in maintaining soil fertility (table 4). In the Sacramento Valley the bean land is often rented to sheepmen after the harvest. The sheep are pastured a few days on the straw. Some straw is sold for fertilizer.

In New York and Michigan bean straw is generally saved. Livestock is plentiful and the relatively severe winters make a lot of feed and bedding essential. The proportion of the bean straw utilized was found to be higher in areas that use the stationary thresher than in areas where combines are generally used. With the stationary thresher the straw can be either stacked or stored in barns as a part of the threshing operation. When the combine is used it usually takes considerable extra labor to collect, bale, and store the straw.

TABLE 4.—*Utilization of dry bean straw by principal producing States, 1943*

State	Acreage harvested 1943	Percentage of straw that was—		
		Used for feed or bedding or sold as:		Not used for feed or bedding, or sold
		Baled straw	Loose straw	
	1,000 acres	*Percent*	*Percent*	*Percent*
New York	113	1. 3	91. 3	7. 4
Michigan	617	4. 4	84. 3	11. 3
Nebraska	80		71. 4	28. 6
Montana	62		78. 0	22. 0
Idaho	168	. 4	58. 8	40. 8
Wyoming	112	1. 0	86. 0	13. 0
Colorado	507	4. 7	70. 0	25. 3
New Mexico	240	25. 0	50. 0	25. 0
California [1]	442	9. 3	4. 6	86. 1
Other States	63	2. 2	57. 5	40. 3
United States	2, 404	5. 2	57. 5	37. 3

[1] For California all data except acreage harvested refer to 1944 crop.

Engebretson, T. O., and Carpenter, C. G. Harvesting Dry Edible Beans and Dry Field Peas. USDA, March 1946. [Processed.]

Bean straw is used for feeding sheep, cattle, or horses in many bean-growing districts. Its feeding value varies widely, but straw of a good grade, especially if fed with some legume hay, may be considered worth about half as much per ton, in terms of net energy, as alfalfa or clover hay. (See table 5.) In the West it is used mainly for wintering livestock and to a limited extent in fattening rations. The United States Department of Agriculture and the New York Agricultural Experiment Station found that about one-sixth of the dry roughage fed to sheep on 49 Yates County, N. Y., farms in 1939 was bean pods and straw. This byproduct is fed to dairy cows, too, in this area.

In the opinion of the staff of the Wyoming Agricultural Experiment Station, one reason that much of this feed has not been used efficiently is that there is little information about its value and the way to use it. In years when alfalfa is scarce in areas that are accustomed to having it, bean straw has been sold for about one-third to one-half of the price of alfalfa. The importance and some of the limitations of bean straw as a feed are suggested in the following summary of a 3-year lamb-feeding experiment in Wyoming:

1. Bean straw when fed as the sole roughage in a lamb-fattening ration did not produce satisfactory gains. The lambs were inclined to eat so much bean straw that they scoured severely and while this did not create a serious death loss, it decreased the rate of gains and gave the lambs a very unthrifty appearance.
2. When bean straw was used to replace one-half of the alfalfa in the ration, the straw had a replacement value equal to the alfalfa and resulted in somewhat larger daily gains. Apparently the lambs favored the bean straw over the

TABLE 5.—*Digestible nutrients of bean straw compared with five other dry roughages* [1]

Roughage	Total dry matter	Digestible protein	Total digestible nutrients	Net energy per 100 pounds
	Percent	*Percent*	*Percent*	*Therms*
Field bean straw	89. 1	3. 0	45. 2	20. 7
Good alfalfa hay	90. 4	10. 3	50. 3	41. 5
Red clover hay	88. 2	7. 0	51. 9	42. 8
Sweet sorghum, dry	89. 2	3. 6	52. 7	34. 3
Corn fodder, very dry	91. 1	4. 1	59. 4	38. 6
Corn tops, dry	82. 1	3. 1	51. 0	

[1] Morrison, F. B. Feeds and Feeding, appendix tables 1 and 2.

alfalfa and if permitted to do so would eat almost exclusively of this roughage. Scouring resulted when the lambs got more than half of the roughage in the form of bean straw.

3. Supplementing bean straw with cured beet tops materially improved the ration and decreased the scouring resulting from the bean straw as fed alone, but did not produce gains as large as the ration in which alfalfa constituted the entire roughage.

4. The value of bean straw depends largely upon the method in which it is used. As the sole roughage its value is low, but as a substitute for one-half of the alfalfa in the ration, its value may be equal to alfalfa hay.

Cracked and unthreshed beans in the straw add to the feed value and unused or surplus straw can be thrown into the feed lot to help build up the manure.

Very little bean straw is used for feed in Idaho, largely because of the change from stationary threshers to combines. If the straw is raked after combining there are many coarse stems. Most of the hulls, leaves, and more palatable parts of the stems are wasted as far as feeding is concerned, but much of this could be saved by using special attachments on the combine. In some cases lambs are turned in to the field after the combining is finished. This should be done immediately after harvest before many of the bean leaves have been blown away.

CULL BEANS FOR FEEDING LIVESTOCK

As Morrison's Feeds and Feeding is so well recognized as an authority, some of the facts in the next three paragraphs are restated from it. (See table 6.)

TABLE 6.—*Digestible nutrients of dry beans for feed compared with four other feeds* [1]

Feed	Total dry matter	Digestible protein	Total digestible nutrients
	Percent	*Percent*	*Percent*
Field beans	88. 2	19. 9	75. 6
Corn, Dent No. 1	87. 2	7. 3	82. 5
Barley, common	90. 4	9. 3	78. 7
Cottonseed meal	93. 5	35. 0	75. 5
Milo grain	89. 4	8. 7	79. 9

[1] Morrison, F. B. Feeds and Feeding, appendix table 1.

Damaged or cull beans, which are sorted out from the first-quality beans, can be used satisfactorily for livestock feeding but their feeding value is less than would be expected from the chemical analysis (table 5). They are not very palatable to stock, and their digestibility is not high when they are fed raw, especially to hogs. Cull beans often include such waste as coarse bits of stem, small stones, and dirt.

Cull beans can well be fed to sheep for they will sort out the beans from the trash. Whole cull beans are satisfactory for lamb fattening, if they are not more than 20 to 25 percent of the grain mixture. A larger quantity may be unpalatable and may cause scouring. But in lamb-feeding tests at Scotts Bluff, Nebr., results were fairly good when beans made up half the grain mixture and were extremely poor when the mixture was 50 to 75 percent beans. In California equal amounts of rolled barley and dry beans fed with alfalfa have given good results in experiments.

If the cull beans are not too "trashy" some can be fed to other livestock. They should be cooked or steamed and mixed with grain if fed to hogs or steers. Ground cull beans can be fed to dairy cows as a substitute for other protein supplements, but they should not be more than a fifth of the concentrate mixture. If they are mixed with more palatable feeds—such as ground corn, ground oats, and linseed meal—the cows are more likely to clean up the feed. More cooked beans can be fed to dairy cows, but cooking is rather expensive and may not be justified.

COMMON DISEASES AND THEIR CONTROL

A large number of diseases attack beans. Some of them may cause serious injury and reduce both quality and yield. In some years the losses have been estimated to run as high as $15,000,000. Diseases of beans are not restricted to certain varieties and types, but some of them are limited by climatic conditions and certain insect carriers. Regardless of the type of bean or the locality, certain diseases are common. They may kill the seedlings; or injure or kill the growing plants; or they may spot and decay the pods and seeds.

Symptoms and other important characteristics of the more common bean diseases and recommendations for their control are summarized here. More detailed discussion is given in Farmers' Bulletin 1692, Bean Diseases and Their Control. Also obtainable from the United States Department of Agriculture are AIS 61, Saving Beans From Mosaic; AIS 62, Saving Beans From Bacterial Blight; and a processed report on Saving Beans From Rust.

ANTHRACNOSE

Bean anthracnose, a seed-borne fungus disease, may cause widespread losses in eastern and southern United States when conditions are favorable for its spread. It is likely to be serious only when the weather is moderately cool, humid, or rainy during the growing season. It may occur on any part of the plant above ground and during almost any stage of growth.

Symptoms.—Seeds affected with anthracnose are characterized by dark sunken lesions, or cankers, which may extend through the seed coat and penetrate the cotyledons. Spores, or seedlike bodies, produced in these lesions are scattered by various agencies and cause infec-

tion of the stem and young leaves; spores produced there in turn become sources of infection for the pods.

On the stems the cankers are oval and sunken and range from brown to nearly black. The fungus may so weaken the stem that it is easily broken in cultivating or by a strong wind.

The anthracnose fungus generally follows the veins on the under side of the leaves, causing them to turn dark red. In a severe attack, dead and angular spots will appear on the upper surface of the leaves.

On the pods the disease is very conspicuous. The first symptom appears as a small reddish-brown area which enlarges and becomes sunken; the center is dark and the border is rusty to brown. During moist weather, spores are produced within the cankers, which have a somewhat pinkish color. The cankers frequently extend through the pod walls, often into the seeds. The fungus may live beneath the seed coat for many months.

CAUSE.—Anthracnose is caused by a parasitic fungus. The spores from the pinkish centers of the cankers are spread by various means to other bean plants, on which they cause new infections.

Wind and rain spread the spores but they may also be carried by insects or on the hands of bean pickers or on farming implements, etc. As the spores are embedded in a substance that sticks to whatever it touches, it is not advisable to go into beanfields when the foliage is wet.

Anthracnose can be carried over from one season to the next on old vines and on infected seeds. It is not known how long the spores will survive under field conditions, but they may live for at least 2 years.

CONTROL.—The most effective control measures are the following: (1) Use disease-free seed. Beans grown in the Mountain region and in all of the States farther west are free of anthracnose. (2) Use crop rotation. Beans should not be planted in an infested field for at least 2 years, preferably longer. (3) Avoid cultivating or entering the field at all while the plants are wet, to prevent spreading anthracnose. (4) Spray. Within the last few years the use of Phygon, Zerlate, or Dithane plus zinc sulfate and lime has given satisfactory control. Seed treatment is of doubtful value.

BACTERIAL BLIGHTS

There are three bacterial blights of beans—halo blight, common blight, and bacterial wilt. The bacteria causing these diseases are different but the symptoms are so similar that one description is enough. Bacterial blights may be widespread wherever beans are subject to frequent rains during the growing season. Only in certain parts of the Mountain, Southwestern, and Pacific Coast States can this crop be grown relatively free of these diseases. In a single place the severity of blight varies greatly from year to year, depending on weather and the presence of infected seeds in the seed lot.

SYMPTOMS.—Blights can be readily recognized in the field. Usually small water-soaked spots on the leaves are the first symptom. These grow larger, turn brown, and finally kill the leaf. Similar water-soaked spots are found on the pods. Commonly the bacteria invade the pod and infect the seeds.

The diseases may appear also on the stem—first as small, watersoaked spots and, later, as reddish dashes. Lesions known as stem girdle, or joint rot, occur at the nodes where the cotyledons were attached. The girdling is usually completed when the pods are half mature. Then

the affected stem, further strained by the increasing weight of the top, breaks at the node.

CAUSE.—Bacterial blights are caused by bacteria. The organisms infecting the different plant parts produce an ooze, particularly on the pods and stems. If spread, this ooze makes new infection centers. The bacteria are spread by wind, rain, hail, and other means from one plant to another. If conditions are favorable they cause new infections.

CONTROL.—Certain measures for the control of blights are the same as those for anthracnose. The use of disease-free seed is the most effective. Seeds produced in certain parts of the Pacific Coast and Mountain States are free or relatively free of infection. As all western-grown seed is not blight-free every year, it is important to know the condition of the crop in the region where the seed originated. As the bacteria may survive in soil, beans should not be planted in an infested field until at least 2 years have passed. As bacteria stick to clothing and machinery, to pick and cultivate when the plants are wet can rapidly spread bacteria from a few infected plants to most of the plants in the field.

No commercially grown varieties have a high resistance to blights. Some—such as Pinto, Great Northern, Red Mexican, and the pea-bean varieties—are fairly tolerant to halo blight.

Treating diseased seeds with chemicals has thus far met with little success. As the bacteria are carried beneath the seed coat, it is difficult to kill them without injuring the seed itself.

COMMON MOSAIC

Common bean mosaic is usually widespread in many bean-growing sections of the United States. Because it rarely kills the plants and the symptoms are frequently hard to see, many growers overlook it and do not realize how important it is, but it reduces yields considerably.

SYMPTOMS.—Leaf mottling of some sort is always evident on plants that are affected with mosaic. The pattern made by the mottled yellow and green areas may vary. Frequently dark-green areas develop near the veins and veinlets of infected leaves. In addition, leaves of very susceptible varieties may be considerably puckered and may have areas that look like blisters or warts. Malformation of leaves is common. In some cases the pods are mottled, undersized, deformed, or rough. Plants that are infected early are often dwarfed. They may produce few flowers and pods; so the yield may be decidedly reduced.

CAUSE.—Bean mosaic is caused by a virus, the nature of which is not well understood. It is known that the virus can be carried from a diseased plant to a healthy one, commonly by plant lice. The virus may spread through the entire plant and into the seeds. Such seeds may look normal but they carry the virus and will produce diseased plants.

CONTROL.—Planting mosaic-resisting varieties is the only satisfactory way of preventing this disease. The resistant varieties of pea beans are Robust and Michelite. Some of the best resistant strains of Great Northern are U. I. No. 15, U. I. No. 59, U. I. No. 81, U. I. No. 123, and Montana No. 1. There are two resistant strains of Red Mexican—U. I. No. 3 and U. I. No. 34. Recently three mosaic-resistant

strains of Pinto have been released. These are U. I. No. 72, U. I. No. 78, and U. I. No. 111.

Roguing the diseased plants from the field is sometimes a practical method of control, but it is temporary and should not be undertaken if a great number of plants are infected. Seeds from rogued fields generally produce higher yielding crops than seeds from nonrogued fields.

A new strain of common bean mosaic virus has been observed during the last few years. It is becoming rather widespread in some of the bean-growing areas of the Mountain States, particularly in southern Idaho. The symptoms it produces are difficult to differentiate from those produced by common bean mosaic. The importance of this virus at present is that several of the popular commercial varieties that are resistant to common bean mosaic are susceptible to the new strain of the virus. The following are susceptible: Great Northern U. I. No. 15, Red Mexican U. I. Nos. 3 and 34, Pinto U. I. Nos. 72, 78, and 111, Robust and Michelite.

The two new Great Northern varieties, U. I. Nos. 16 and 31, released by the Idaho station are resistant to the new virus and to common bean mosaic and curly top. These varieties are similar to Great Northern U. I. No. 15.

RUST

Bean rust is perhaps the most important disease of dry beans in the irrigated sections of several of the Mountain States. From 1940 to 1945 it was a potential menace to about 225,000 acres in these States.

Bean rust develops and spreads most readily when the humidity is high. Heavy vine growth which shades the ground and prevents proper air circulation produces an ideal condition for rust. Under humid conditions the disease may spread so rapidly that in a short time all the plants in a field may be infected.

Symptoms.—Bean rust attacks principally the leaves. The first symptoms appear on the lower surface as small, white spots, or flecks. Within a few days these develop into rust-colored lesions or pustules about the size of pinheads. As many as 2,000 have been counted on a single leaf. A week or so after these appear, the entire leaf begins to yellow. Later it turns brown, dries up, and falls from the plant.

Cause.—Rust is caused by a fungus that has several stages. A farmer usually notices only the summer stage, which shows up as reddish-brown pustules containing thousands of reddish-brown spores. These are blown about by the wind and spread the disease from plant to plant and from field to field. Toward fall the rust produces another kind of spore, which is black. They are very hardy and live over winter.

Control.—When finely ground sulfur is applied to beans as a dust fairly early in the season before the rust spots appear, the disease can be controlled. Sulfur destroys the comparatively few rust pustules present at that time. Spread of spores from these spots is stopped, and other spots are prevented. If dusting is done after the rust is widespread, more applications of dust are required and the control is not so complete.

Beans planted on land that grew a heavily infected crop the previous year will show rust much earlier in the season and the disease will be more serious on them than on beans planted on new land. A 2-year rotation with beans following some other crop is sufficient.

Beans should not be planted close to stacks of old bean straw that harbor rust spores. If they are, they may become infected earlier in the season than those planted elsewhere.

All of the common varieties of dry beans are susceptible to rust. For farmers who grow Pinto beans, the two new rust-resistant Pinto varieties called No. 5 and No. 14 are recommended.

CURLY TOP

Curly top of beans has been known since 1926. It is found in Idaho, Washington, Oregon, California, and several other States. In most of these States the disease is not serious every year, but when there are many beet leafhoppers, which transmit curly top, the bean crop may be ruined.

SYMPTOMS.—Plants affected with curly top are decidedly dwarfed. Young plants show the most pronounced symptoms on the trifoliate leaves, which pucker, curl downward, and show a clearing of the veins. Sometimes the leaves resemble small green balls. The young leaves frequently cease to develop, turn yellow, and curl downward. They are thicker than normal and very brittle, readily breaking off from the main stem. A plant thus affected generally dies before the pods develop. The disease is not seed-borne.

CAUSE.—The cause of curly top is a virus but it is distinctly different from the virus that causes bean mosaic. The disease is spread from plant to plant by the beet leafhopper, which is frequently referred to in some western sections as the "white fly." Before infecting a bean plant the leafhopper must have fed on some plant that is infected with curly top—such as beans, beets, tomatoes, et cetera. The symtoms appear about 10 days to 2 weeks after infection.

As the disease is not transmitted except by leafhoppers, curly top is prevalent only where the insect thrives. The severity of the disease depends on the number of leafhoppers.

CONTROL.—No fully effective control measures for curly top have been developed, but several resistant varieties are known. Great Northern U. I. Nos. 15, 16, and 31; Red Mexican U. I. Nos. 3 and 34, and Pinto U. I. Nos. 72, 78, and 111, which are resistant to the disease, can be safely grown where the disease is prevalent. As curly top is not seed-borne, good seed that originate where the disease is present can safely be planted in any part of the country.

ROOT ROTS

Several different organisms may cause root rot of beans. The symptoms are so similar that sometimes it is hard to tell them apart. Root rots occur wherever beans are grown, but on the whole they cause more damage to the crop in the Southern States.

SYMPTOMS.—Root rots as a group are characterized by the formation of cankers on the stem below the soil level and on the fibrous roots. The cankers may be of various sizes and shapes and may be gray, brown, black, or brick red. The fibrous roots are often decayed.

CAUSE.—Root rots are caused by several different fungi that live in the soil on decomposed vegetable matter. They can attack beans as well as many other crops, when soil and other conditions are unfavorable for the best plant growth. None of these fungi are seed-borne.

CONTROL.—No effective control for the root rots is known. Using certain cultural practices to improve general growing conditions of

beans will considerably reduce the severity of these diseases. The most effective control is a 5- to 6-year rotation. The cropping system should include cereals, clover, and alfalfa—plants on which the bean root-rotting organisms rarely if ever cause any lasting damage. As root-rot organisms naturally live in practically all soils, they cannot be entirely eliminated. All that can be done is to make conditions so favorable for the bean plant that it will thrive in spite of the parasites that may be in the soil.

SCLEROTINIA WILT

Sclerotinia wilt, also known as white mold, causes heavy losses, especially in some parts of the South. Within the last few years it has been serious in some of the bean-producing areas of the Mountain States. The disease frequently occurs after a period of warm, humid weather. A few days of such weather may cause large crop losses.

SYMPTOMS.—The first symptoms appear as irregular-shaped, water-soaked spots on the stems, followed by similar spots on the branches and leaves. The organism grows rapidly, causing a somewhat soft watery rot of the affected parts. If several days of warm, wet weather follow the infection, a cottony growth spreads over the branches and leaves. A few days later, irregular-shaped, hard, black, charcoal-like bodies, varying from one-fourth to one-half inch in diameter, known as sclerotia frequently occur in large numbers. These are the resting bodies of the fungus. The plant usually dies within a few days.

CAUSE.—Sclerotinia wilt is caused by a fungus. The sclerotia which live in the soil during the winter have considerable resistance to heat and cold. After a period of cold weather and in the presence of moisture, the sclerotia produce spore-bearing bodies. If the spores lodge on a susceptible plant a new infection may begin.

CONTROL.—No adequate control measures are known. The sclerotia produced in the soil and on diseased plants are difficult to remove or destroy. Sanitary measures, such as the removal or destruction of diseased plants, should be used when practicable.

A rotation of 2 or 3 years or longer with such crops as corn and other cereals should be used, if possible. Planting beans in rows far enough apart to allow proper air circulation in a field may prevent a high field humidity and may reduce the infection.

POWDERY MILDEW

Powdery mildew is rather widely distributed throughout the United States, but it is more abundant in the Southern States and along the Pacific coast than elsewhere. It is uncommon in the Mountain area. It may develop so rapidly that a crop may be severely damaged within a few days.

SYMPTOMS.—The earliest symptoms are slightly dark areas that may be mistaken for mottling. These areas later develop into small white powdery spots, which enlarge and join with others to form an almost complete coating of a whitish, chalklike powder over the leaf. The leaves turn pale yellow. If the attack is severe they fall off.

Infected pods may be stunted, malformed, and poorly filled. Often they fall off without bearing seeds. Infected pods and stems may be purplish.

CAUSE.—Powdery mildew is caused by a fungus. The spores are found in large numbers on the leaves, pods, and stems. They are carried by the wind and other agencies from plant to plant.

CONTROL.—Powdery mildew can readily be controlled with one or two dustings of sulfur. The first application should be made when the disease first appears. The second should follow within a week or 10 days.

ROOT KNOT

Root knot is mostly found in the light sandy soils of the South and in similar areas in California. Beans of all kinds are highly susceptible. In some fields half the crop may be lost. The nematodes have been so bad on some farms that growing of beans has been discontinued.

SYMPTOMS.—Root knot is characterized by enlarged, irregularly shaped, deformed, fleshy galls on the root system. Occasionally the galls may be confused with the nodules that normally develop on the roots of beans, lima beans, and other legumes. Careful comparison will show the two to be quite different. Root knot should be suspected when the leaves are somewhat pale and the plants are dwarfed and later begin to die.

CAUSE.—Root knot is caused by a parasitic eelworm, or nematode, so small that it can scarcely be seen by the naked eye. It enters the small roots and causes them to form the irregular swellings or galls. These galls cut off the carrying of food material from the roots to the rest of the plant. The small nematodes live in the soil in the winter.

CONTROL.—The most satisfactory method of controlling root knot is to rotate with immune crops for three or more years. Some of these are beggarweed, crotalaria, oats, and rye. Clean cultivation may prevent growth of susceptible weeds on which the nematode could feed. The use of certain chemicals such as DD and ethylene dibromide as soil fumigants is also recommended. They should be used as recommended by the manufacturers.

COMMON INSECTS AND THEIR CONTROL

MEXICAN BEAN BEETLE

The adult Mexican bean beetle is hard-shelled and copper-colored and has 16 black spots on its back, or 8 on each wing cover. It is oval and about one-fourth of an inch long. It is common in the Rocky Mountain States and is found generally in the Eastern States. The adult beetles move from their hibernating quarters into the fields when warm weather first comes. At Fort Collins, Colo., for example, the movement takes place during the first 2 weeks of June, and the larvae are hatched between June 25 and August 10 from the masses of yellow eggs placed on the underside of the leaves. The yellow fuzzy-looking larvae do the principal damage, feeding on the underside of leaves.

The most effective control for the Mexican bean beetle is a spray containing ground derris or cube root powder. This powder, with a rotenone content of 4 percent, should be used at the strength of 1½ pounds in 50 gallons of water. Cryolite is also useful and should be used at the rate of 3 pounds in 50 gallons of water. Arsenate of zinc, 2 pounds to 100 gallons of water, has been generally used in Colorado.

According to Farmer's Bulletin 1915, Snap Beans for Marketing, Canning, and Freezing, dusting as a rule does not give as good results as spraying. A dust containing derris, or cube (4 percent rotenone), 12½ pounds, and talc, sulfur, clay, or other diluent, 87½ pounds may be used. Pyrethrum dust containing 0.5 percent of total pyrethrins or an impregnated dust containing 0.3 percent total pyrethrins may be substituted for rotenone sprays or dust but is not quite so effective.

Calcium arsenate or cryolite dust are also used effectively in some areas, but they are poisonous and should be handled with care and applied only before the pods begin to form.

The bean beetle is not difficult to control if the insecticide is applied to the underside of the leaves where the larvae feed (fig. 11). The

FIGURE 11.—Dusting beans, eight rows at a time with a tractor-driven duster. This is an effective and economical method of controlling certain insects and diseases.

Colorado Experiment Station reports in Bulletin 482, Field Bean Production Without Irrigation in Colorado, that under conditions of light infestation one application of spray or dust gives a practical control. This application should be made as soon as injury by the larvae becomes apparent. It is important to apply the insecticides in such manner as to cover the undersides of the leaves thoroughly. Do not delay until the foliage is seriously skeletonized. If the adults appear in the field in such numbers that their injury is apparent during June or the forepart of July, an application should be made to stop their feeding and egg laying, with a second application when larvae injury appears. Nonirrigated beans rarely warrant more than two treatments, although three are often found practical under irrigation.

GRASSHOPPERS

In the Central and Western States particularly, grasshoppers sometimes do considerable damage to the crop. They eat the leaves, pods,

and stems. The ones that attack crops lay their eggs in the soil during summer and fall. The eggs remain in the ground during the winter and hatch during April, May, and June.

One of the best methods of control is the use of poisoned bait, supplemented by tillage and seeding methods which restrict egg laying and imprison the young grasshoppers in the soil after they hatch. Bait is best used while grasshoppers are still on their hatching grounds or massed along the edges of the field. Often using bait along the borders of a beanfield may prevent serious damage. Cooperation in the use of control methods by all the farmers in a community is necessary for best results. Many counties operate a bait-mixing plant, often under the supervision of the County Agricultural Agent, who can give advice regarding the proper use of the bait.

The bait generally used is made according to the following formula:

Mill-run bran, mixed feed, or shorts	pounds	25
Sawdust (3 times bulk of mill-run bran)	bushels	3½
Sodium fluosilicate	pounds	4–6
Water	gallons	10–12

One hundred pounds of a good flaky type of wheat bran may be substituted for the mill-run bran and sawdust specified in the above formula.

The bait should be broadcasted thinly in the infested area at the rate of about 20 pounds (wet weight) per acre.

As sodium fluosilicate is toxic to man and domestic animals, proper care should be used in mixing, handling, and spreading. Bulk quantities of the bait must be kept away from children and livestock. When properly spread, however, the bait can be used safely in fields pastured by livestock.

Recent experiments have shown that grasshoppers can be controlled effectively by the direct application of a dust or spray containing chlordane or a chlorinated camphene to the infested areas. Results obtained with benzene hexachloride dusts and sprays, although generally good, have been more variable.

When sprays are used, apply 1 pound of technical chlordane or 1½ pounds of technical chlorinated camphene per acre. When dusts are used, apply 1½ pounds chlordane or 2 pounds of chlorinated camphene per acre. Late in the season, when grasshoppers are mostly adult and vegetation is tall and dense, it may be necessary to increase these dosages slightly.

Chlordane and chlorinated camphene are marketed as emulsion concentrates, wettable powders, and dusts of various strengths. Emulsion concentrates and wettable powders may be diluted with water to suit available spraying equipment but, whatever the formulation or dilution, the quantity of technical material applied per acre should conform to the above recommendations. It must be remembered that all of these insecticides are toxic to man and warm-blooded animals and must therefore be handled with care. Forage treated with these new insecticides should not be fed to dairy animals, or to meat animals that are being finished for slaughter.

SPOTTED CUCUMBER BEETLE

This beetle is about ¼ inch long, is yellow green, and has six spots on each wing cover. It eats holes in the leaves and damages the pods.

Beans grown east of the Rocky Mountains are subject to some damage each year from this beetle. A closely related species damages beans in California, Washington, and Oregon. Spray or dust, the same as used for the Mexican bean beetle, is recommended to control this beetle.

SEED-CORN MAGGOT

According to Farmers' Bulletin 1915, Snap Beans for Marketing, Canning, and Freezing, the seed-corn, or bean, maggot attacks the germinating seed or the seedling in the soil. It may destroy the seed before the seedling can emerge, or it may only result in damaged and unproductive seedlings. This insect is especially destructive in cold, wet soils in the spring and in soils containing large quantities of nondecayed or partly decayed organic matter. There is no known method of control after infestation occurs; so preventive measures must always be taken against it.

Damage by the seed-corn maggot can best be avoided or minimized by careful attention to the following: (1) Plant beans only on soils in which green manure, cover crops, weeds, or sod have been turned under long enough to become well rotted. (2) Plant relatively shallow in warm, well-drained soil. (3) Avoid applying manure immediately before growing beans. (4) Avoid the use of commercial fertilizers high in organic constituents such as bonemeal, tankage, and fish scrap. (5) Avoid planting at a time the maggots are known to be abundant in the soil.

BEAN WEEVIL

Farmers' Bulletin 1275, Weevils in Beans and Peas, discusses in detail the bean weevil and its control, but the following statement from Leaflet 223, Growing Field Beans in Humid Areas, indicates briefly the highlights of the problem:

The bean weevil is such a serious pest in regions having mild winters that beans can rarely be grown at a profit in such regions. Even in the more northerly States where most of the country's beans are grown, this weevil is a major problem. The beans may become infested either in the field or in storage, or both. There follow a number of control methods that should all be carefully followed:

(1) Plant weevil-free seed. . . . (2) Harvest and thresh or shell all seeds from weevil-infested fields as soon as they are ripe. . . . (3) Immediately after they are harvested (and threshed), place the seeds in tight bags having at least 24 strands to the linear inch. . . . (4) Fumigate infested seeds as soon as possible after harvest. . . . (5) Eliminate all shattered seeds and other crop remnants that may remain on the field surface after harvest, by clean plowing, burning, pasturing with livestock, or any other available method . . . (6) Clean up possible hibernating or overwintering quarters of weevils, adjacent to or near cultivated fields, such as brush-filled fence rows, abandoned orchards, and dilapidated fences and buildings . . . (7) Beans, cowpeas, or peas stored on the farm, in warehouses, or in other storage places should be examined at frequent intervals and fumigated when necessary.

Fumigation should not be undertaken without thorough information and preparation. It is hazardous.

BEET LEAFHOPPER

The beet leafhopper is one of the worst scourges that afflict agriculture in most States west of the Rocky Mountains. It affects sugar beets and tomatoes as well as beans. It is found in some other areas, including Kansas, western Texas, New Mexico, and Colorado. The beet leafhopper is a plant-sucking insect, but its principal damage is in spreading the virus that causes curly top. It does not live throughout the year on the cultivated crops, but on noncultivated host plants, chiefly weeds on nonagricultural lands or on lands that are not farmed steadily. These weedy lands are the breeding areas of this pest.

Control of this leafhopper involves the proper use of range land and areas that are farmed only occasionally. Reducing weeds in the breeding areas and replacing them with annual and perennial grasses should reduce the leafhoppers, increase forage production, and decrease soil erosion.

In areas where the value of the land and crops is fairly high and the host plants are only in small areas, hand hoeing and other mechanical means of destroying the host plants may be justified. In the California breeding grounds the leafhoppers are forced to small patches of perennial weeds during the fall. This makes it feasible to kill large numbers of the pest in the foothill breeding areas, so there are fewer in the spring. Fall spraying was begun by two sugar companies in the fall of 1931 and has been done each fall since then, except for 2 years during the war. They use a spray that is a mixture of ½ to 1 pound of pyrethrum extract per gallon of Diesel fuel oil, applied at the rate of 5 to 7 gallons an acre. Experiments with the use of DDT on bean plants are under way, but further work must be done to provide a basis for definite recommendations.

Those who are interested in more than a summary statement should read Farmers' Bulletin 1886, The Beet Leafhopper.

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